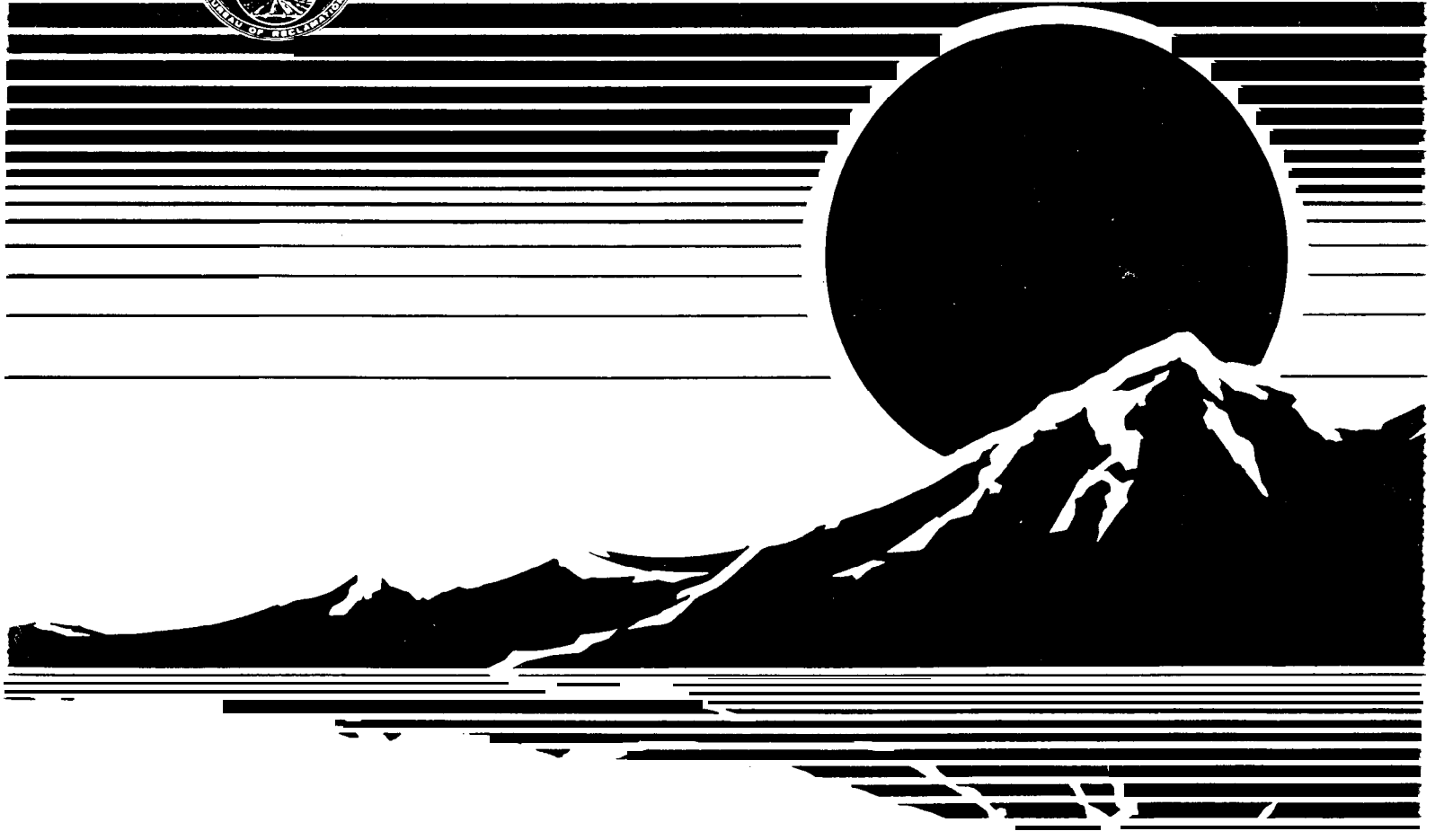
GLOBAL CLIMATE CHANGE RESPONSE PROGRAM

Inventory of Hydrologic Models

August 1991



GLOBAL, CLIMATE CHANGE RESPONSE PROGRAM

INVENTORY OF HYDROLOGIC MODELS

AUGUST 1991

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER, COLORADO

MISSION STATEMENTS

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian Reservation Communities and for people who live in Island Territories under U.S. Administration.

"The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public."

Requests for additional copies of this publication sbould be sent to the **Bureau of Reclamation, Denver Office, P.O. Box 25007, D-7923A, Denver,** Colorado **80225.**

PREFACE

Global climate change is a change in the climate of the earth occurring either naturally or as a result of human influence. Of particular concern is "anthropogenic" global warming, which is a warming of the Earth's atmosphere caused by the influence of humans on the natural environment. Anthropogenic global warming is the result of an increase in atmospheric concentrations of carbon dioxide, methane, chlorofluorocarbons, and other "greenhouse" gases, which trap additional heat in the atmosphere. The increase in greenhouse gases is caused by the consumption of fossil fuels (coal, petroleum, and natural gas), land use modification, and the release of agricultural and industrial gases into the atmosphere.

Global climate change may threaten water-dependent ecosystems unless adequate preparations are taken. It has the potential to affect water demands, water supplies, and water management. It could affect the quantity of precipitation and runoff, the seasonal timing of precipitation and runoff, and the severity of storms, floods, and droughts.

The Bureau of Reclamation (Reclamation) supplies municipal water to 25 million people in 17 Western States, provides irrigation water for 10 million acres of farmland, and operates 52 hydroelectric facilities which generate approximately 48 billion kilowatt-hours of electricity annually, making Reclamation the nation's 11th largest electric utility. In addition, Reclamation facilities provide flood control, recreation, fish and wildlife enhancement, and environmental management.

As Reclamation has the responsibility to wisely manage water resources while ensuring that associated environmental assets are preserved, the impacts of global climate change on water resources and environmental assets need to be identified and appropriate responses studied.

Of concern are the impacts on agriculture, municipal and industrial water supplies, hydroelectric power generation, water quality, fisheries, wetlands, riparian communities, and recreation. Also of concern are the impacts on reservoir operations, flood control, drought management, and distribution of water for beneficial uses.

The Global Climate Change Response Program, a multiyear Reclamation research program, is designed to study the potential impacts in the 17 Western States, and to determine the impacts on water demands, water supplies, and water management. This program will endeavor to develop strategies and responses to deal with these impacts through a broad range of research activities, research projects, and technical studies.

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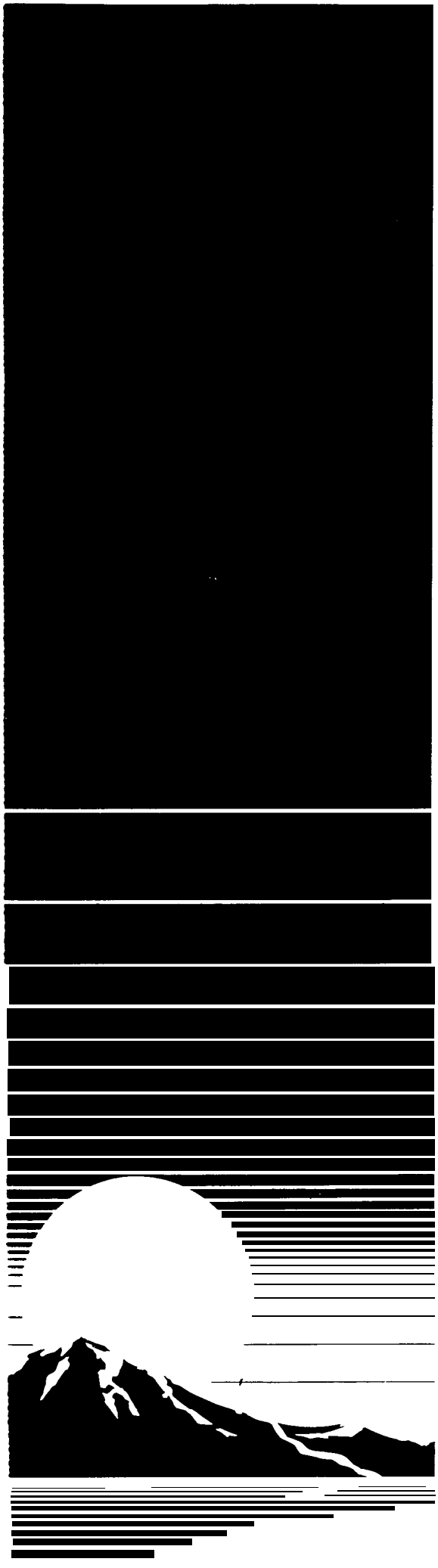

INTRODUCTION

INVENTORY OF HYDROLOGIC MODELS

INTRODUCTION

A common challenge to hydrologists and engineers involved in hydrologic simulation is to answer the question, "which hydrologic model should be used?" In order to answer this question, one must first address the question "which hydrologic models are available?" Compiling a complete list of available hydrologic models, even in a specific category, is a difficult if not impossible task to perform in most cases.

This document presents a relatively detailed inventory of well known and reputable hydrologic models used and supported by the Bureau of Reclamation (Reclamation) for several key hydrologic processes, and a representative sample of similar models used and supported by other organizations. These models are generally limited to addressing evapotranspiration and demand processes, precipitation-runoff processes, and project and river system operations.

The compiling of this inventory was undertaken to determine the availability of hydrologic models that could assist in identifying the potential impacts of global climate change on water resources. The inventory was funded by Reclamation's Global Climate Change Response Program.

The first phase of the inventory focused on models maintained and supported by Reclamation which could be of interest to other Reclamation offices and others outside the organization. The second phase collected information on a number of models used and supported by other organizations'.

DEVELOPMENT OF EVALUATION FORM

An important preliminary task was to develop an evaluation form which would summarize relevant information about each model in a concise and readable format. This form would assist readers to become familiar with the capabilities and limitations of each model and determine whether they wanted to obtain additional information and, if so, whom to contact. A copy of the form was reviewed by key participants and then distributed to the appropriate modeling experts.

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[1] A'comprehensive, detailed survey of all such models was not within the scope of this effort.

TECHNICAL CONTACTS

In the first phase, a team of hydrologists from the Denver Office Surface Water Branch (D-5750)' contacted Reclamation personnel in the Denver, Regional, and Project offices. The initial contacts were based on the models known to the team. Subsequently, the evaluation form was distributed to all Regional offices with a request to involve appropriate Project offices under their jurisdiction.

The second phase involved contacting a representative set of outside agencies and organizations. A literature search was done through Reclamation's Denver Library to gain additional information on water demand models which might be available. A total of twelve other organizations (including government agencies, universities, and private organizations) responded.

SUMMARY OF RESPONSES

A total of 64 models were inventoried through the responses. The responses covered both site-specific and generally applicable models. No effort was made to screen or otherwise compare the models and the inclusion of any model in the inventory does not necessarily signify Reclamation's endorsement of the model. A tabulation summarizing the models by categories follows:

		Number of Models Inventoried	
Category	Models	Site Specific	Generally Applicable
I	Water Requirements	2	12
II	Precipitation - Runoff	0	11
III	Project and River System Operations	23	13
IV	Other Related	0	3

SUMMARY OF MODELS INVENTORIED BY CATEGORY

The evaluation forms from each response were used in the form provided by the respondents except in cases of obvious grammatical omissions or cases where the volume of material provided was so large and diverse as to require editing.

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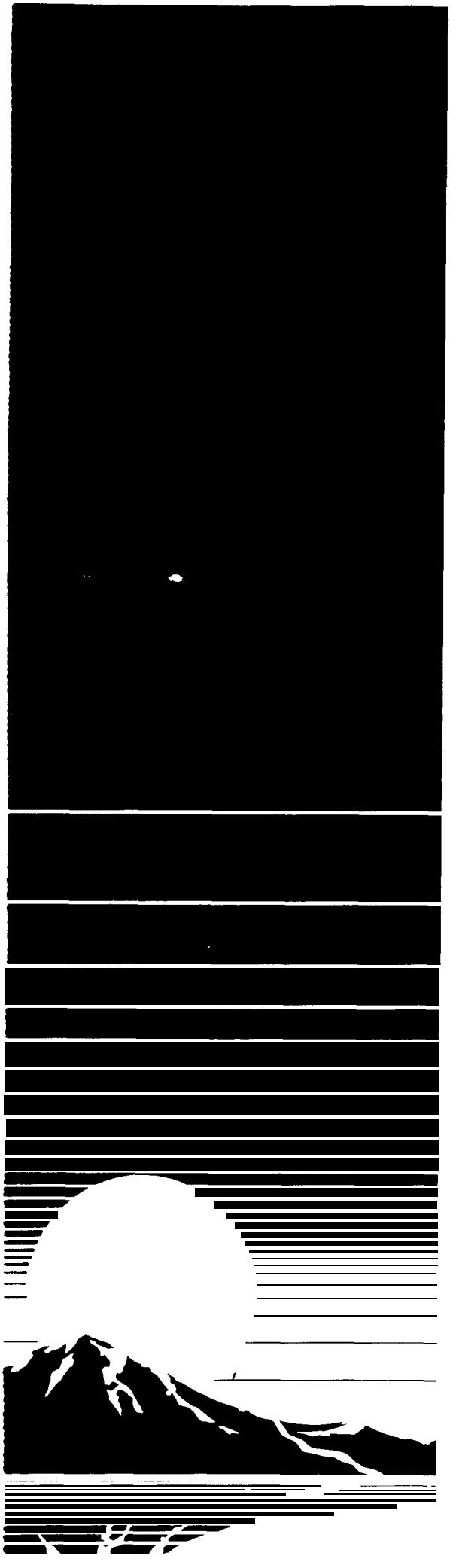
[2] Don Frevert, Craig Albertsen, Sharon Nuanes, Eldon Johns, and Bill Lane



CATEGORY I

Category I

Water Requirements Models

Fourteen evaluations of models in this category were received. These were primarily generally applicable models, many of which were developed by and for the Bureau of Reclamation (BOR). Others were developed by Oklahoma State University (OSU), the University of Idaho (UI), and California State University (Cal. State).

Name of Model	Organization
Utah Area Water Demand Model	BOR
REACH (Water Supply and Demand for Tualatin Basin)	BOR
XCONS (Blaney Criddle Consumptive Use)	BOR
XETCMP (Multi Method Consumptive Use)	BOR
Interactive Consumptive Use Package	OSU & BOR
PEAKWRN (Jensen - Haise Sizing Program)	BOR
XCIR (Jensen - Haise Consumptive Use)	BOR
CONUSE2 (Consumptive Use, Diversions, Return Flows, Depletions)	BOR
BASIN (Delivery and Diversion Requirements, Recharge, Outflow, Rainfall-Runoff Modeling)	BOR
WMC (Water Management and Conservation) PACKAGE	BOR
REF80 (Daily Crop Evapotranspiration)[1]	BOR
WAT80 (Daily Water Requirements)'	BOR
On-Farm Irrigation	UI
SPACE (Sprinkler Profile and Coverage Evaluation)	Cal. State

[1] These programs can be obtained individually, or as part of the Water Management and Conservation Package of programs.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Utah Area Water Demand Model

FUNCTION: Evaluate future water supply and demand alternatives

AGENCY & OFFICE: USBR - Utah Projects Office

TECHNICAL CONTACT: Roger Hansen 801-379-1101
FTS-584-1101

MACHINE COMPATIBILITY: IBM PC - 386 (640 KB base memory), math coprocessor, 40MB hard disk, VGA high resolution monitor and a pointing device.

DOCUMENTATION: Available

SPATIAL PRECISION: Covers metropolitan areas using GIS

TEMPORAL PRECISION: Projects into future. Predicts mean annual, daily and peak hourly demands.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Has numerous defaults which allow easy use, but also allows custom fit assumptions to be used.

STRENGTHS: Very flexible. User friendly. Can be set up for any area.

WEAKNESSES: Data intensive. Presently configured for the Salt Lake City metro area.

INPUT **REQUIREMENTS:** Base maps, water system boundaries, water demand sectors, economic data.

OUTPUT PRODUCED: Mean annual, average and maximum daily and hourly peak demands.

HYDROLOGIC MODELS **INVENTORY**

EVALUATION FORM

NAME OF MODEL: REACH

PUNCTION: Monitors water supply and demand during the irrigation season on the Tualatin River and major tributaries.

AGENCY & OFFICE: USBR - PN Regional Office, Boise, Idaho

TECHNICAL CONTACT: Monte McVay (PN 435) 208-334-1176
FTS-554-1176

MACHINE COMPATIBILITY: Any machine with a FORTRAN compiler.

DOCUMENTATION:

SPATIAL PRECISION: Six Tualatin River Control Points, two on tributaries.

TEMPORAL PRECISION: Can be updated daily.

OVERVIEW OF CAPABILITIES, **ASSUMPTIONS:** Can be and has been used by Tualatin Valley Irrigation District for monitoring irrigation district water demand and summertime streamflows in the Tualatin River and major tributaries; could be applied in other areas with modification.

STRENGTHS : A supply and demand model in one program.

WEAKNESSES: No documentation to speak of and needs modification for application in other areas.

INPUT REQUIREMENTS: Streamflow data (near real-time); list of WMC **WAT80** program (water requirements model) state approved water permits.

OUTPUT PRODUCED: Irrigation demand, M&I demand, current streamflow in various reaches, current list of water permits for natural flow which are junior to existing flow.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: XCONS

R'UNCTION: Estimates monthly crop evapotranspiration using the Blaney-Criddle Method

AGENCY & OFFICE: USBR - Denver Office - Water Resources Section

TECHNICAL CONTACT : Eldon John3 (D5752) 303-236-3810
FTS 776-3810

MACHINE COXPATIBILITY: CDC Cyber Main Frame

DOCUMENTATION: Self documenting in program listing. Reference: Irrigation Water Requirements, Technical Release No. 21, Soil Conservation Service, September 1970.

SPATIAL PRECISION: Point estimates based on weather station locations.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Provide3 monthly estimates of consumptive use and crop irrigation requirement (net irrigation requirement) and allow3 for overall estimates weighted by crop. Assumes that consumptive use is a function of temperature, precipitation, location and crop phenology only.

STRENGTHS : Simple to operate and modify. Easy to read results.

WEAKNESSES: An old program which ha3 had extensive modification by a number of different individuals.

INPUT REQUIREMENTS: Climate (temperature, precipitation and growing season) and crop phenology.

OUTPUT PRODUCED: Monthly evapotranspiration and crop irrigation requirement (net irrigation requirement) estimates. Estimates of effective precipitation using the SCS method.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: XETCMP

FUNCTION: Estimates daily crop evapotranspiration using 16 different methods or variations

AGENCY & OFFICE: USBR - Denver Office - Water Resources Section

TECHNICAL CONTACT: Eldon Johns (D5752) 303-236-3810
FTS 776-3810

MACHINE COMPATIBILITY: CDC Cyber Main Frame

DOCUMENTATION: "Comparison of Equations Used for Estimating Agricultural Crop Evapotranspiration with Field Research" by R.W. Hill, E.L. Johns, and D.K. Frevert, Bureau of Reclamation, October 1983.

SPATIAL PRECISION: Point estimates based on weather station locations.

TEMPORAL PRECISION: Daily (summations give monthly)

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Allows comparisons of strengths and weaknesses of various predictive equations. This model is mainly a research tool. Assumptions vary with each of the methods.

STRENGTHS : Easy comparison of many widely used methods. Thoroughly tested.

WEAKNESSES: Rather extensive input/output requirements.

INPUT REQUIREMENTS: Daily climate and related data including temperature, precipitation, solar radiation, humidity, wind speed and crop phenology.

OUTPUT PRODUCED: Daily evapotranspiration estimates for crops by various predictive methods.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: **An** interactive package of programs for estimating consumptive use:

MAPSTA
ETKNOW
ETBC, ETJH, ETPEN
ETPLOT

FUNCTION: Interactive Software for Estimating Evapotranspiration

AGENCY & OFFICE: USBR - Denver Office - Water Resources Section (Software will eventually be supported by the Agricultural Engineering Department, Oklahoma State University, Stillwater, Oklahoma)

TECHNICAL CONTACT: Eldon Johns (D5752) 303-236-3810
FTS 776-3810
Ronald L. Elliott 405-744-8423

MACHINE COMPATIBILITY: 386 series Personal Computers

DOCUMENTATION: Self **documenting. References in various** ASCE **(American Society of Civil Engineers) and ASAE** (American Society of Agricultural Engineers) papers. These include: "Estimating Evapotranspiration With a Knowledge-Based System" by R.L. Elliott, E.L. Johns and P.A. Weghorst, Paper Number 897575 presented at the International Winter Meeting of ASAE, New Orleans, December 12-15, 1989 and **"An** Interactive Computer System for Estimating Monthly Evapotranspiration" by R.L. Elliott, E.L. Johns and P.A. Weghorst in the *Proceedings of the 1990 National Conference on Irrigation and Drainage, Durango,* **Colorado,** ASCE.

SPATIAL PRECISION: Point estimates based on weather station locations.

TEMPORAL PRECISION: Monthly

OVERVIEW OF **CAPABILITIES,** ASSUMPTIONS: Displays of station location, monthly computation of consumptive use by crops (ultimately by three methods although only the Blaney-Criddle is presently available), plotting of consumptive use estimates. Assumptions vary depending on method used.

STRENGTHS : User friendly, interactive operation. Graphical capabilities facilitate the package's application.

WEAKNESSES: In developmental stage. Improved capabilities are needed for various modules. ETJH (Jensen-Haise) and ETPEN (Penman) need to be developed.

INPUT REQUIREMENTS: Climate and related data including temperature, precipitation, solar radiation, humidity, and crop phenology.

OUTPUT **PRODUCED:** Monthly evapotranspiration estimates for crops by (ultimately) three different predictive methods. Selected plots of input and output data.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: **PEAKWRN**

FUNCTION: Estimates daily evapotranspiration data for project facility sizing.

AGENCY & OFFICE: USBR - Denver Office - Water Resources Section

TECHNICAL CONTACT: Eldon Johns (D5752) 303-236-3810
FTS 776-3810

MACHINE COMPATIBILITY: CDC Cyber Computer System

DOCUMENTATION: Documentation available in draft form. Referenced in "Estimating Irrigation Water Requirements," U.S. Bureau of Reclamation, September 1970.

SPATIAL PRECISION: Point estimates based on weather station location.

TEMPORAL PRECISION: Daily or multiple day increments.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Focuses strictly on sizing of project facilities (pumping plants, canals and pipelines). Assumes Jensen-Haise method accurately computes consumptive use. Assumes no effective precipitation.

STRENGTHS : Flexibility in providing estimates for varying time intervals (1 day, 3 day, 5 day, etc.) and allows for different crop distributions. Well tested and technically sound.

WEAKNESSES : Substantial data requirements. Specialized to sizing applications. Assumptions related to effective precipitation are very conservative.

INPUT REQUIREMENTS: Climate and related data including temperature and solar radiation, crop phenology and soils data.

OUTPUT PRODUCED: Conveyance Sizing Curve and related support data.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OR' MODEL: XCIR

FUNCTION: Estimates monthly evapotranspiration using the Jensen-Haise method. (1970 Jensen-Haise Procedure)

AGENCY & OFFICE: USBR - Denver Office - Water Resources Section

TECHNICAL CONTACT: Eldon Johns (D5752) 303-236-3810
FTS 776-3810

MACHINE **COMPATIBILITY:** CDC Cyber Computer System

DOCUMENTATION: Documentation available in the computer file XCIRDOC but is incomplete.

SPATIAL PRECISION: Point estimates based on weather station locations.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, **ASSUMPTIONS:** Allows computations by Jensen-Haise method with and without elevation correction.

STRENGTHS : Well tested and generally technically sound.

WEAKNESSES: An old program which has undergone extensive modification. The Jensen-Haise method should be used with caution in high altitude areas where it tends to overestimate evapotranspiration.

INPUT **REQUIREMENTS:** Climate and related data including temperature, solar radiation, precipitation and crop phenology data.

OUTPUT PRODUCED: Monthly evapotranspiration estimates for individual and weighted agricultural crops, effective precipitation is computed using the USBR Method, and crop irrigation requirements (net irrigation requirements).

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: CONUSE2

FUNCTION: Calculates consumptive use, diversions, return flows, depletion requirements, annual depletions and current levels of depletion

AGENCY & OFFICE: USBR, Great Plains Region, Water Management Branch

TECHNICAL CONTACT: Rick DeVore (GP451) 406-657-6637
FTS-585-6637

MACHINE COMPATIBILITY: VAX 6200 (plan to convert **to PC)**

DOCUMENTATION: Description in Missouri Basin States Association Hydrology Study, 1982.

SPATIAL PRECISION: Determined by user and the irrigated area he/she specifies.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can estimate consumptive use with both Blaney-Criddle and Jensen-Haise methods at any location. Estimates solar radiation for Jensen-Haise method based on percent of possible sunshine.

STRENGTHS : Combines five functions (previously five programs) into a single operation.

WEAKNESSES: Limited to two consumptive use methods (Blaney-Criddle and Jensen-Haise).

INPUT REQUIREMENTS: Temperature and precipitation data, percent of possible sunshine, crop acreage and phenological data, return flow distribution pattern, irrigation efficiencies and irrigated area.

OUTPUT PRODUCED: Consumptive use and crop irrigation requirement for each crop, weighted crop irrigation requirement, diversions, return flows and depletion requirements (monthly in acre-ft/acre) - based on acres - Diversion requirement in acre-ft, available return flow in acre-ft, depletions in acre-ft and a current level of depletions for the period of record.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: BASIN

FUNCTION: The BASIN program computes -
1. Irrigation farm delivery requirements,
2. Project diversion requirements,
3. Ground-water recharge, or
4. Basin outflow depending on the purpose of the study.

The program will also compute streamflow depletions or net change in ground water recharge due to a change in cropping patterns or irrigated acreage.

AGENCY & OFFICE: Bureau of Reclamation
Nebraska Kansas Projects Office
Grand Island, NE

TECHNICAL CONTACT: Duane Woodward (307-261-5608)
North Platte River Projects Office
Mills, WY 82644

MACHINE COMPATIBILITY: The program is written in Fortran IV and is on the Cyber EE system.

DOCUMENTATION: There is a "USERS" manual developed by Fred Otradovsky and dated **5-21-81.** The program uses are explained along with the input data requirements and example runs are provided.

SPATIAL PRECISION: The program can calculate information for a Basin area, Project area, farm size area or computation can be made for a unit area. The study area can be divided into ten areas, each defined by a specific soil-rain gage combination.

TEMPORAL PRECISION: The BASIN model makes computation on a monthly time step by year.

OVERVIEW *OF* CAPABILITIES ASSUMPTIONS: Monthly computations of evapotranspiration by crop can be made using four ET methods three versions of Jensen-Haise and the Blaney-Criddle (TR-21). The ground water discharge is computed by the R.E. Glover methods. Monthly rainfall infiltration by soil is taken from curves developed using rainfall versus runoff data collected by ARS-USDA. The program does a monthly soil moisture budget of the crop root zone to determine when recharge will take place and determine the number of irrigation applications required to maintain soil moisture for a crop. Basic assumptions are:

1. The soil reservoir is the effective root zone of a given crop.
2. The maximum amount of moisture which can be stored in the soil reservoir is the "Available Water" equal to "Field Capacity" minus "Wilting Point".
3. The portion of rainfall that infiltrates the soil is equal to the total rainfall on a field size area less runoff from that area.
4. Evapotranspiration includes transpiration from plants plus evaporation from soil and plant surface.

5. The movement of water from the soil reservoir to the zone of saturation (water table) is immediate and without loss.
6. Surface water outflow from an area is equal to the runoff from field size areas less losses to evaporation and seepage and occurs within the same month as the rainfall.

STRENGTHS : It is a monthly water budget model that accounts for total precipitation as runoff, infiltration, soil moisture storage, evapotranspiration, or recharge.

WEAKNESSES: The location of effective precipitation stations to the area being modeled usually limits how well it calibrates to the area.

INPUT REQUIREMENTS: Monthly climate data, temperature, precipitation, and solar radiation. Area soil properties data, area cropping patterns, irrigation water use efficiency, and percent of area dryland, well irrigated, and canal irrigated.

OUTPUT PRODUCED: Tables of input data, crop consumptive use, farm delivery or diversion requirement, monthly net ground water recharge, and annual hydrologic water budget from which net recharge or net basin outflow are displayed.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: WMC (Water Management and Conservation) Package

FUNCTION: To forecast irrigation requirements of an irrigation system

AGENCY & OFFICE: USBR - Denver Office - Facilities Engineering Branch

TECHNICAL CONTACT: Dave King (D-5210) 303-236-8322
FTS-776-8322

MACHINE COMPATIBILITY: IBM-PC

DOCUMENTATION: User's manual available

SPATIAL PRECISION: Determined by user input

TEMPORAL PRECISION: Daily

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Three levels of use are available: Intensive field by field scheduling, general scheduling and systemwide scheduling.

STRENGTHS: Newer versions have numerous PC enhancements

WEAKNESSES: 3rd version is being developed using DBASE IV while 2nd version (in BASIC) is in limbo.

INPUT REQUIREMENTS: Canal system data such as farm turnouts, deliveries, water orders and field irrigation scheduling data.

OUTPUT PRODUCED: Accounting summary of system water use and forecasted water use.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: **REF80** (Part of WMC **-** Mini 80 Package)

FUNCTION: Daily crop evapotranspiration calculations from climate data.

AGENCY & OFFICE: USBR **-** PN Regional Office, Boise, Idaho

TECHNICAL CONTACT: Allen R. Powers **(PN** 437) 208-334-1176
FTS-554-1176

MACHINE COMPATIBILITY: VAX Computer (written in FORTRAN)
PC Computer (written in BASIC)

DOCUMENTATION: Considerable documentation available in WMC User's Manual.

SPATIAL PRECISION: N/A

TEMPORAL PRECISION: N/A

OVERVIEW OR' CAPABILITIES, ASSUMPTIONS: Seasonal consumptive use modeling for multiple crops given crop growth functions, planting dates and daily climatic information.

STRENGTHS: Fairly versatile and simple to operate seasonally once set up and daily climate data imputing is automated.

WEAKNESSES: Not very user friendly **-** presently undergoing some code modifications to update crop modeling methodologies and expand outputs.

INPUT REQUIREMENTS: Formatted climate, crop curve and reference crop files.

OUTPUT **PRODUCED:** Updated daily crop file and crop water use chart.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: WAT80

FUNCTION: Water requirements computations on large blocks of land using cropping patterns and climatic data.

AGENCY & OFFICE: USBR - PN Regional Office, Boise, Idaho

TECHNICAL CONTACT: Jerry Buchheim (PN 405) 503-773-2002
FTS-554-1153

MACHINE COMPATIBILITY: IBM PC Compatible with DOS using BASIC A interpreter. Version also available written in FORTRAN IV.

DOCUMENTATION: WMC Reference manual (October 18, 1984) including input field descriptions and schematics showing interactive computation methods. The WAT80 program is one of 29 modular programs within the WMC computer program system.

SPATIAL PRECISION: Multiple control points, representing irrigated lands configured as districts, canal systems, lateral systems within one climatic area.

TEMPORAL PRECISION: Daily - Limited to a maximum of 15 days new data per update throughout season on near real-time basis.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: This computer package is designed to be run from menus to allow ease of operation. The WAT80 model focuses on computing daily, weekly, monthly or seasonal water requirements for large or small areas where rainfall may contribute significantly to the crop consumptive use.

STRENGTHS: Currently extensively used in GCCRP Rogue River Basin studies.

WEAKNESSES: Limited use and demonstration during first six years after development.

INPUT REQUIREMENTS: Formatted climatic and agronomic data

OUTPUT PRODUCED: Water Requirement output in "printout" or file form for selected control points.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Microcomputer Program Development for On-Farm Irrigation System Planning

FUNCTION: Analysis of on-farm irrigation'system plans

AGENCY & OFFICE: Mr. B. King
Mr. B Sauer
Mr. J. Busch
University of Idaho
Department of Agricultural Engineering
Moscow, ID **83843**

TECHNICAL CONTACT: B. King

MACHINE CONPATIBILITY: MS-DOS IBM Compatible

DOCUMENTATION: Microcomputer program development for on-farm irrigation systems planning. Research technical completion report, Idaho Water Resources Research Institute. University of Idaho, Moscow ID **83843**

SPATIAL PRECISION:

TEMPORAL PRECISION: Half-monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Models the soil-crop-system interaction of on-farm irrigation systems showing inadequacies in the system plan, if any. Assumes half-monthly time step is sufficient for evaluating irrigation system adequacy

STRENGTHS : Shows soil-crop-system interactions

WEAKNESSES: No user support; requires Lotus Symphony for data entry. Does not compute potential ET

INPUT REQUIREMENTS: Potential ET, rainfall, soil and crop characteristics, water and labor availability, irrigation system components and layout, water, labor and energy lost.

OUTPUT. PRODUCED:
1. Adequacy of irrigation for all crops grown in rotation.
2. System limitations causing irrigation shortfalls.
3. Capital and operational costs including the effects of inflation.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: SPACE - Sprinkler Profile and Coverage Evaluation

FUNCTION: Evaluating performance of sprinklers for given spacings.

AGENCY & OFFICE: California State University
Center for Irrigation Technology
Fresno, CA **93740**

TECHNICAL CONTACT: Joe Oliphant

MACHINE COMPATIBILITY: IBM PC, **G40K,** Graphics Card, Dot-Matrix printer, DOS 2.1 or later

DOCUMENTATION: Fully documented

SPATIAL PRECISION: **N/A**

TEMPORAL PRECISION: N/A

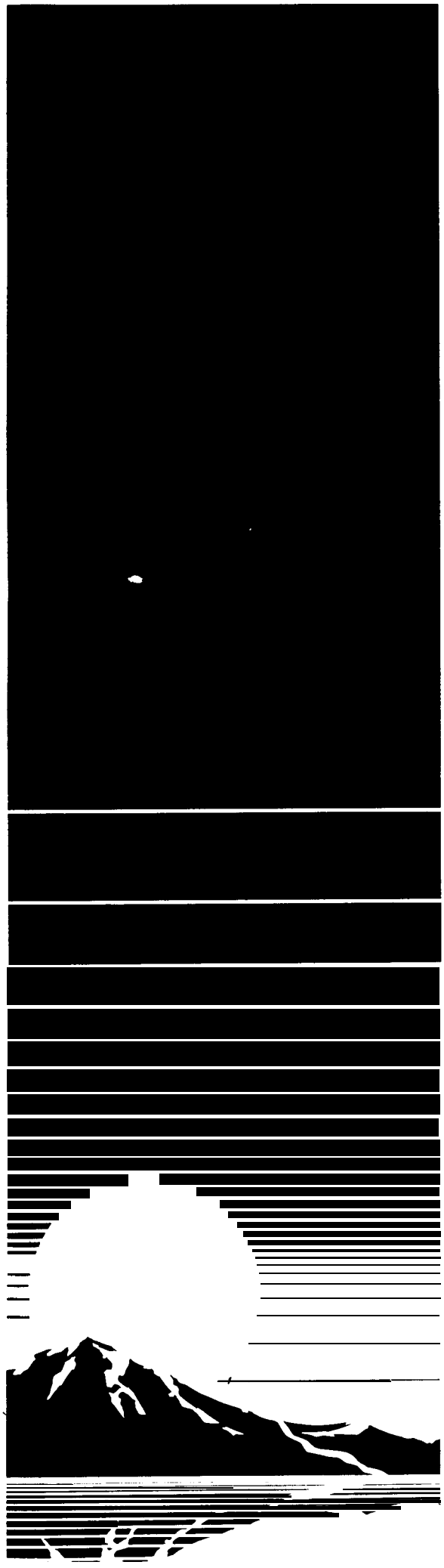
OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Calculate CU, DU, average, minimum, and maximum application rates. Calculates "scheduling coefficient", run-time multiplier based on efficiency of the sprinkler performance. For single-leg tests, assumes symmetrical performance over the arc of the sprinkler.

STRENGTHS: Any number of spacings can be done once the sprinkler has been tested.

WEAKNESSES: Only applicable to fixed, repeating spacing designs.

INPUT REQUIREMENTS: Lateral and sprinkler head spacings.

OUTPUT **PRODUCED: "Densogram" -** a graphical image of the water application over the overlapped area. Efficiency coefficients, CU, DU, and scheduling coefficients. Sensitivity analysis for scheduling coefficient based on a **1%, 2%, 5%,** and 10% window size and the single driest catchment. The window size is based on the percentage of the overlapped area. The scheduling is a run-time multiplier - it tells how much longer the system must run to get enough water to the dry *window'.



CATEGORY II

Category II

Precipitation - Runoff Models

Eleven models in this category included primarily models developed and supported by other Federal agencies - Agricultural Research Service (ARS), Soil Conservation Service (SCS), Geological Survey (GS), Corps of Engineers (Corps), along with one Bureau of Reclamation (BOR) model, and one model supported by Colorado State University (CSU). All of the models are generally applicable, provided that the required input data are available.

Name of Model	Organization
FHAR (Rainfall-Runoff and Flood Hydrograph Model)	BOR
IRS (Infiltration and Runoff Simulation)	ARS
KINEROS (Runoff/Erosion in Planes and Channels)	ARS
TLOSS5 (Runoff, Peak Discharge and Losses)	ARS
WEPP (Overland Flow and Hill Slope Erosion)	ARS
CREAMS/GLEAMS (Agricultural Hydrology, Water Quality and Erosion)	ARS
TR20 (Flood Hydrographs and Routing)	SCS
TR55 (Urban Storm Runoff)	SCS
HEC-1 (Rainfall and Snowmelt Runoff Hydrographs)	Corps
PRMS (Watershed Response to Rainfall or Snowmelt)	GS
RUNOFF (Urban Watershed Runoff)	CSU

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OR' MODEL: **FHAR**

FUNCTION: Calculates runoff from rainfall and produces a flood hydrograph and performs hydrologic routing.

AGENCY & OFFICE: USBR - Denver Office - Flood Section

TECHNICAL CONTACT: Ken Bullard (D5751) 303-236-3797
FTS 776-3797

MACHINE COMPATIBILITY: Personal Computer.

DOCUMENTATION: This program has been documented by "Interim Documentation for the **FHAR** Program," by Robert Main, April 1988. In addition, documentation updates exist for subsequent changes and improvements to the model. These include "Creating Version Number 4.11 of **FHAR,"** "Creating Version Number 4.12 of **FHAR,"** "Changes to the **FHAR** Program made in Creating Version **4.13,"** and **"FHAR** Program Version 4.14," January 24, 1990.

SPATIAL PRECISION: Subbasins are treated as hydrologically and meteorologically homogeneous areas. Average values are used for parameters and inputs for each individual subbasin. Precision may be altered by changing the number and sizes of the subbasins.

TEMPORAL PRECISION: Time increments are selected to match the particular application. Typical time increments used vary from 15 minutes to 3 or 4 hours depending upon precipitation inputs, hydrologic response time and drainage area.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Calculates runoff hydrographs starting with precipitation increments. A variety of methods are available for accounting for infiltration and other losses. Options are available for both river and reservoir routing along with the ability to combine hydrographs. Several input procedures are available and the model can be run in more than one manner. Intermediate results can be examined as the modeling progresses.

STRENGTHS : Versatile, very easy to apply, uses standard methods, well tested and technically sound. Revised modeling accomplished with a minimum of additional effort. Can be run in a user friendly interactive mode.

WEAKNESSES: Designed for planning and design flood studies. The model is not readily applicable to real time and operational studies.

INPUT **REQUIREMENTS:** Hydrologic runoff and routing parameters, and precipitation inputs.

OUTPUT PRODUCED: Calculations and hydrographs, in well designed tables and also in forms for use in further modeling or for use in other programs such as graphics or text processing programs.

HYDROLOGIC MODELS INVENTORY

EVALUATION ***FORM***

NAME OF MODEL: IRS-Infiltration and runoff simulation

FUNCTION: Computes amounts and rates of infiltration and runoff on an overland flow surface.

AGENCY & OFFICE: USDA-ARS
2000 E Allen Rd
Tucson AZ 85719

TECHNICAL CONTACT: Jeffry J. Stone FTS-762-6481
602-670-6381

MACHINE COMPATIBILITY: VAX VMS, UNIX, PRIME, PC's DOS

DOCUMENTATION : In house user manual.

SPATIAL PRECISION: Computes hydrograph at one point

TEMPORAL PRECISION: Minimum time step = 1 minute

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: All assumptions associated with Green and Ampt infiltration equation and kinematic wave model, capable of using time varying rainfall.

STRENGTHS :
1. Semi-analytical solution of Kinematic wave model.
2. Parameter default values.
3. Interactive.
4. Fast.

WEAKNESSES :
1. Only applies to a single plane.
2. Infiltration is not interactive with Kinematic wave model.

INPUT REQUIREMENTS: Time intensity rainfall, Green and Ampt parameters, slope length and gradient, and Chezy or Manning coefficient.

OUTPUT PRODUCED:
1. Table of rates and amounts of rainfall infiltration, rainfall excess.
2. Hydrograph plot file.
3. ***Summary*** of totals.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: KINEROS

FUNCTION: Computes runoff and erosion on planes and in channels.

AGENCY & OFFICE: USDA-ARS
2000 E. Allen Rd.
Tucson AZ 85719

TECHNICAL CONTACT: Research Leader
Southwest Watershed Research Center
602 670-6381
FTS-762-6481

MACHINE COMPATIBILITY: VAX VMS, IBM PC Compatible

DOCUMENTATION: Extensive technical and user guide.

SPATIAL PRECISION: A few square meters to several square kilometers.

TEMPORAL PRECISION: Down to 1 minute step

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Kinematic wave model for runoff events. Simplified erosion model and choice of sediment transport relationships.

STRENGTHS: Good hydraulics, validated on small watersheds, infiltration similar to Green-Ampt. Distributed.

WEAKNESSES: Erosion and sediment transport options not validated. Event, not continuous simulation, model does not deal with snowmelt.

INPUT REQUIREMENTS: Detailed watershed topography, distributed channel network, dimensions, and linkage. Distributed rainfall, infiltration, and hydraulic roughness parameters.

OUTPUT PRODUCED: Runoff peaks and volumes on planes and in channel network. Runoff hydrographs and sediment yield for individual events.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: TLOSS5

FUNCTION: Computes runoff volume, peak discharge, and transmission losses (infiltration loses to channel bed and banks) on semiarid watersheds.

AGENCY & OFFICE: USDA-ARS
2000 E. Allen Rd.
Tucson AZ 85719

TECHNICAL CONTACT: Leonard J. Lane - 602 670-6381
FTS-762-6481

MACHINE COMPATIBILITY: IBM PC Compatible

DOCUMENTATION:
1. An-code documentation.
2. ASCE Journal Publications.
3. User Guide under development.

SPATIAL PRECISION: 1 hectare to about 25 sq km. Rainfall, curve numbers, and channel properties can vary in space.

TEMPORAL PRECISION: Computes total storm runoff, peak discharges, and transmission losses - an individual event model.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can compute runoff volumes, peaks, and transmission losses from historical storm rainfall amounts or from rainfall frequency data. Computes potential groundwater recharge from floods in stream channels.

STRENGTHS : Simple, event model. Most input from tables, default values, and rainfall frequency. Has been calibrated in southwest.

WEAKNESSES: Uses modified SCS runoff curve number technology, only an event model (not continuous simulation). Only validated in southwest (Arizona and New Mexico). Does not deal with snowmelt.

INPUT **REQUIREMENTS:** Watershed geometry: channel lengths and widths, hydraulic conductivity, contributing areas, network linkage. Runoff curve numbers, hydrograph shape parameters, rainfall data.

OUTPUT PRODUCED:
1. Runoff peaks and volumes and transmission losses.
2. A water balance for each event.

HYDROLOGIC MODELS INVENTORY

EVALUATION **FORM**

NAME OF MODEL: WEPP Hillslope Version

FUNCTION: Compute erosion and sediment yield from hillslopes and representative overland flow profiles (USLE Replacement).

AGENCY & OFFICE: **USDA-ARS**
National Soil Erosion Lab.
Purdue University
West Lafayette, IN 47907

TECHNICAL CONTACT: Dr. J. M. Laflen

MACHINE COMPATIBILITY: IBM-PC Compatible, VAX, UNIX, etc.

DOCUMENTATION: Extensive, technical and user's guide.

SPATIAL PRECISION: 1 meter - 100 or more meter hillslopes

TEMPORAL PRECISION: Minimum time step 1 minute, computes storm, daily, monthly, and annual erosion and sediment yield.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Modern erosion model based on hydrology, hydraulics, erosion mechanics, sediment transport and deposition.

STRENGTHS : State-of-the-art erosion model. Continuous simulation. Includes climate generator and rainfall disaggregation procedures. Will be official USDA model.

WEAKNESSES: Still under validation and testing--not officially released yet by USDA.

INPUT REQUIREMENTS: Files for climate, topography, soils, management (Croplands and Rangelands).

OUTPUT PRODUCED: Within storm, storm by storm, daily, monthly, and annual output: climate, hydrology, crop growth, erosion, and sediment yield.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: CREAMS & GLEAMS

FUNCTION: Agricultural water quality: hydrology, erosion, nutrients, and pesticides from field-sized areas.

AGENCY & OFFICE: USDA-ARS
P.O. Box 948
Tifton, GA 31793

TECHNICAL CONTACT: Research Leader - Southeast Watershed Research

MACHINE COMPATIBILITY: IBM PC Compatible & many others.

DOCUMENTATION: User guides and extensive technical publications.

SPATIAL PRECISION: Field-scale applications.

TEMPORAL PRECISION: Continuous simulation, daily time step

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Extensively tested and documented and accepted widely. Computes storm, daily, monthly, and annual water balance, sediment yield, nutrient yield, and pesticide yield.

STRENGTHS : Extensively tested and documented. Good user manuals.

WEAKNESSES: Limited to field scale (less than 10^1-10^3 acres). Cumbersome rainfall input format. Lack of graphic output.

INPUT REQUIREMENTS: Soil, LAI, temperature, radiation data, topographic data, cropping-management data, daily precipitation data.

OUTPUT PRODUCED: Storm by storm, daily, monthly, annual, and average outputs; water balance, erosion and sediment yield, chemical yields.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: TR-20 - Computer Program for Project Formulation Hydrology

FUNCTION: Assists in hydrologic evaluation of flood events by developing, adding reach and reservoir routing hydrographs.

AGENCY & OFFICE: USDA - Soil Conservation Service
National Headquarters
Engineering Division
Washington, D.C.

TECHNICAL CONTACT: Donald E. Woodward FTS-475-5342

MACHINE COMPATIBILITY: IBM and compatible personal computers.

DOCUMENTATION: TR-20 - Computer Program for Project Evaluation Hydrology (1983)

SPATIAL PRECISION: Subwatersheds up to 25 square miles - Total watershed area up to several hundred square miles, subject to temporal precision limits.

TEMPORAL PRECISION: Times of concentration 0.1 hr. to 48 hrs.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can route through 99 structures, 200 stream reaches, 99 alternates, 10 storms, 9 different rainfall distributions. Uses Modified Attenuation - kinematic method for reach routing and storage indication method for reservoir routing, initial abstraction = .2S.

STRENGTHS : User friendly, uses easily obtainable input data, can do a variety of alternatives.

WEAKNESSES: No provision for runoff losses from seepage or other causes, initial abstraction assumed = .2S, where S = potential maximum retention after runoff begins.

INPUT REQUIREMENTS: Drainage area, curve number, time of concentration, rainfall type and amount, channel cross section rating and reservoir elevation-discharge-storage curves.

OUTPUT **PRODUCED:** Hydrographs, cross section discharge-end area plots, summary tables with peak discharge rates, times and elevations.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: TR-55 - Urban Hydrology for Small Watersheds

FUNCTION : Simplified procedures to calculate storm runoff volume, peak discharge rates, hydrographs and storage volumes.

AGENCY & OFFICE: USDA - Soil Conservation Service
National Headquarters
Engineering Division
Washington, D.C.

TECHNICAL CONTACT: Donald E. Woodward FTS-475-5342

MACHINE COMPATIBILITY: IBM and compatible personal computers.

DOCUMENTATION: TR-55 - Urban Hydrology for Small Watersheds, USDA-SCS, (1986)

SPATIAL PRECISION: Where temporal limit applies, generally a few acres to several square miles.

TEMPORAL PRECISION: Times of concentration 0.1 hr. to 10 hrs.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Assumes open and unconfined flow over land or in channels, initial abstraction = .2S where S = potential maximum retention after runoff begins.

STRENGTHS : User friendly, uses easily available data.

WEAKNESSES: Tables with specific Tc and Tt values, output at one point, no reservoir routing, no rainfall intensity factor in runoff equation, or accounting for snow or frozen ground.

INPUT REQUIREMENTS : Drainage area, curve number, times of concentration and travel, rainfall type and amount.

OUTPUT PRODUCED: Storm runoff volumes, peak discharge rates, hydrographs, storage volumes.

HYDROLOGIC MODELS **INVENTORY**

EVALUATION FORM

NAME OF MODEL: HEC-1

FUNCTION: Calculates runoff from rainfall and snowmelt and produces a flood hydrograph and performs hydrologic routing.

AGENCY & OFFICE: US Army, Corps of Engineers
Hydrologic Engineering Center
609 Second St.
Davis, California 95616

TECHNICAL CONTACT: Hydrologic Engineering Center 916-756-1104

MACHINE **COMPATIBILITY:** Personal Computer.

DOCUMENTATION: Program documented by "HEC-1, Flood Hydrograph Package, User's Manual," (1990). Updated as changes are made.

SPATIAL PRECISION: Subbasins are treated as hydrologically and meteorologically homogeneous areas. Average values are used for parameters and inputs for each individual subbasin. Precision may be altered by changing the number and sizes of the subbasins.

TEMPORAL PRECISION: Time increments are selected to match the particular application. Typical time increments used vary from 15 minutes to 3 or 4 hours depending upon precipitation inputs, hydrologic response time and drainage area.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Calculates runoff hydrographs starting with precipitation increments. Provisions are also made for the calculation of snowmelt runoff. A variety of methods are available for accounting for infiltration and other losses. Options are available for both river and reservoir routing along with the ability to combine hydrographs.

STRENGTHS : The program is well maintained, versatile, fairly easy to apply, uses standard methods, thoroughly tested and technically sound. It is also capable of simulating flow over and through breached dams.

WEAKNESSES: Designed for planning and design flood studies. The HEC-1 model is not readily applicable to real time and operational studies. However, another version, **HEC-1F,** effectively handles real time situations. Presently lacks menuing capabilities that may be available with other personal computer programs.

INPUT **REQUIREMENTS:** Hydrologic runoff and routing parameters, and snowpack, temperature, and precipitation inputs.

OUTPUT PRODUCED: Calculations and hydrographs in tables. Limited graphics are available using character plotting.

HYDROLOGIC MODELS INVENTORY

EVALUATION **FORM**

NAME OR' MODEL: **PRMS** (Precipitation - Runoff Modeling System)

FUNCTION: Simulates the effects of various combinations of climate and land use on watershed response.

AGENCY **&** OFFICE: U.S. Geological Survey
Water Resources Division
Denver, Colorado

TECHNICAL CONTACT: George H. Leavesley FTS-776-5026
303-236-5026

MACHINE COMPATIBILITY: Mainframe, minicomputer, microcomputer, PC-DOS, UNIX workstation.

DOCUMENTATION: Leavesley, G.G., Lichty, R.W., Troutman, B.M. and Saindon, L.G., 1983, Precipitation - Runoff Modeling System -- User's Manual: U.S. Geological Survey Water Resources Investigations 83-4238, 207 p.

SPATIAL PRECISION: < 1 ha. to 10000 square km.

TEMPORAL PRECISION: Variable time step - 24 hr time step in daily mode and 1 minute to 60 minutes in storm mode.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Watershed response to normal and extreme rainfall and snowmelt. Can be simulated to evaluate changes in water balance relations, flow regimes, flood peaks and volumes, soil-water relations, sediment yields and ground-water recharge. Distributed parameter capabilities are provided by partitioning watershed using slope, aspect, elevation, vegetation, soils, and precipitation characteristics.

STRENGTHS : Distributed parameter, physically based, variable time step, optimization and sensitivity analysis capabilities included. Statistical analysis capabilities and extended streamflow prediction capabilities tested in wide range of hydrologic conditions.

WEAKNESSES: No channel routing currently in 24 hr time step, sediment transport conservative in channel, no chemical quality component.

INPUT REQUIREMENTS: Daily precipitation, max and min temperature and solar radiation for 24 hour time step (solar radiation estimated if not available). Precipitation in 1 to 60 minute increments for storm mode. Basin characteristics describing topography, soils, vegetation, geology and climate.

OUTPUT PRODUCED: Streamflow, all water balance components, and all state variables for the complete basin and for each subarea defined in the basin for each 24 hour time step. Daily, monthly and annual averages of these values are also computed. Storm hydrographs and sediment graphs for each user selected overland flow plane and channel or reservoir node at the storm time interval.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: RUNOFF

FUNCTION: Generalized urban watershed runoff prediction model for urban stormwater planning and management. The model includes water quality routing as well as detention storage routing.

AGENCY & OFFICE: Department **of** Civil Engineering, Colorado State University

TECHNICAL CONTACT: John W. Labadie, Professor 303-491-8596

MACHINE COMPATIBILITY: IBM PC or compatible version available; also running on VAX stations under VMS.

DOCUMENTATION: User manual and documentation available.

SPATIAL PRECISION: Currently dimensioned for up to 100 subbasins; designed primarily for urbanized or urbanizing areas.

TEMPORAL PRECISION: Primarily an event-driven model but can be used for continuous simulation; can be run at 5 minute time steps and an unlimited number of total time steps.

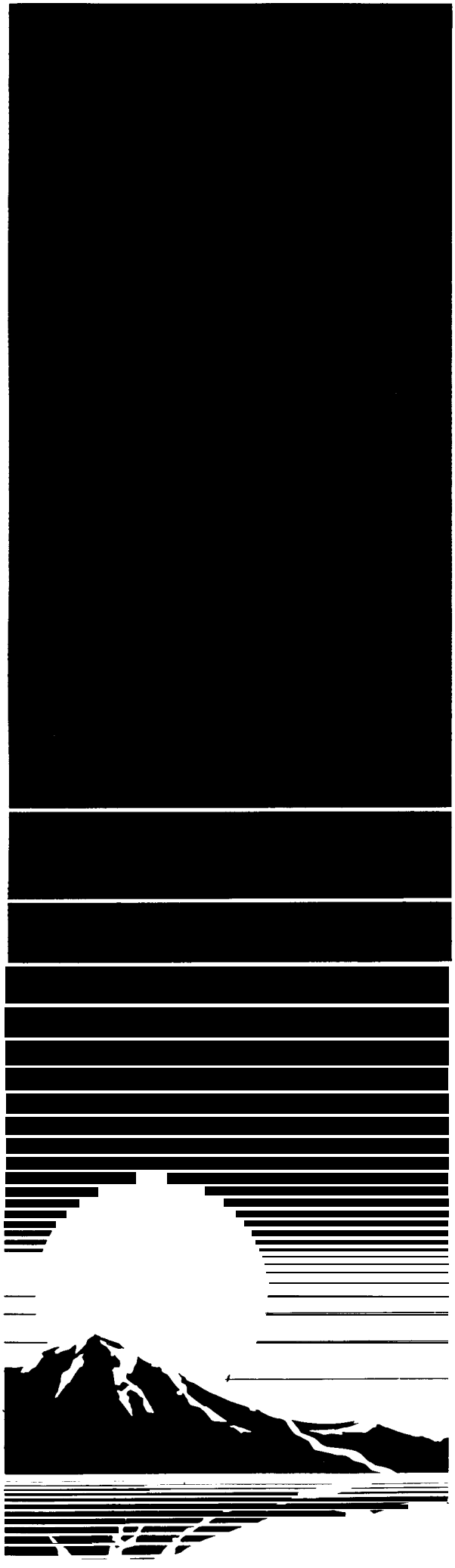
OVERVIEW OF CAPABILITIES, ASSUMPTIONS: RUNOFF is a physically-based simulation model employing kinematic wave assumptions for calculating overland flow and minor drainage flow; employs physically-based Green-Ampt infiltration model; employs assumptions similar to EPA's SWMM model for water quality routing. Is currently being used by Metro Seattle for real-time urban stormwater control.

STRENGTHS : RUNOFF is similar to the RUNOFF component of the EPA SWMM model, but is considerably more efficient and conducive to real-time runoff prediction for urban stormwater management, whereas SWMM is primarily a planning model.

WEAKNESSES: Does not include some of the extended features of **SWMM,** such as the **snowmelt** routines in SWMM; also, is not as well suited for continuous simulation as SWMM.

INPUT REQUIREMENTS: Includes a fully interactive data input preprocessor with editing capability; requires much of the same input requirements as the EPA SWMM model. Since RUNOFF is primarily a physically-based model, it is less dependent on real-time urban runoff data for calibration, as opposed to more black-box models employing unit hydrographs and synthetic unit hydrographs.

OUTPUT PRODUCED: An interactive graphical based output postprocessor is available with the VAX VMS version of RUNOFF. The PC version provides hardcopy output on runoff hydrographs and pollutographs for various water quality constituents--high'speed printer plots are also available on most output information.



CATEGORY III

Category III

Project and River System Operations Models

Thirty-six models in this category were inventoried. The majority of these models are supported by the Bureau of Reclamation (BOR) and more than half are site specific. Inventories were also received from the Corps of Engineers (Corps), Salt River Project (SRP), Colorado State University (CSU), and Cornell and Texas A&M universities.

Name of Model	Organization
CRSS (Colorado River Simulation System)	BOR
FAOP (Fryingpan-Arkansas Operations Model)	BOR
Bighorn Basin Annual Operating Plan Model	BOR
North Platte Annual Operating Plan Model	BOR
Colorado Big Thompson Annual Operating Plan Model	BOR
Fryingpan-Arkansas Annual Operating Plan Model	BOR
Western Division Hydropower Summary Model	BOR
Western Division Annual Operating Plan Model	BOR
PROSIM (Central Valley Project Simulation)	BOR
SANJASM (San Joaquin Area Simulation)	BOR
CVGSM (Central Valley Surface and Ground Water)	BOR
FORCIS (Central Valley Operational Forecast Model)	BOR
Truckee-Carson Water Operations Model	BOR
BHOPS (Lower Colorado Daily Operations)	BOR
Colorado River 24 Month Study Model	BOR
GLENREL (Operation of CRSP Reservoirs)	BOR
Animas-La Plata Project Operations Model	BOR
Dolores Project Operations Model	BOR
SRPSIM (Salt River Project Operations Model)	SRP
CAPSIM (Central Arizona Project Operations Model)	BOR
YKMODEL (Yakima Basin Simulation Model)	BOR
Water Supply Forecasting for Eastern Colorado Projects Office Basins	BOR

Category III

Project and River System Operations Models (continued)

TAMUWRAP (Monthly Reservoir Operation and Water Rights)	Texas A&M
Water Operations Technology Package	BOR
PNMOD (Reservoir Operation and Routing)	BOR
DROPH (Daily and Hourly Reservoir Operation)	BOR
WORK17C (Single Reservoir Operation Study)	BOR
River Network Model	BOR
HYDROSS (Hydrologic Operations Study System)	BOR
PNRRN (Monthly Reservoir System Simulation)	BOR
OPSTUDY (Utility Program for Monthly Operations)	BOR
SSARR (Streamflow Synthesis and Reservoir Reg.)	Corps
HEC-5 (Operation of Reservoir - Channel Systems)	Corps
SIMULOP (River - Reservoir Operations Simulation)	BOR
IRIS (Interactive River Simulation Program)	Cornell
MODSIM (River Basin Network Simulation Model)	csu

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Colorado River Simulation System (CRSS)

FUNCTION: Performs monthly hydrologic simulations of the Colorado River System

AGENCY & OFFICE: USBR Denver Office, Water Management Section

TECENICAL CONTACT: Dennis O'Connor (D5755) 303-236-5248
FTS-776-5248

MACHINE COMPATIBILITY: Control Data Cyber

DOCUMENTATION: *Colorado River Simulation System - Executive* Summary, Ronald J. Schuster, U.S. Bureau of Reclamation, April *1987. Colorado River Simulation System - System Overview,* U.S. Bureau of Reclamation, May 1985. Additional documentation available on request.

SPATIAL PRECISION: Basin is divided into 25-30 reaches with each reach capable of simulating one reservoir and as many as ten inflow and 10 diversion points. In turn each diversion point can include as many as 10 individual demands.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Model simulates streamflows, reservoir inflows, contents, releases and power generation, deliveries and water quality (in terms of total dissolved solids). The model utilizes a basic assumption of mass balance and, due to its monthly timeframe, does not consider travel time. Additional assumptions are described in the documentation.

STRENGTHS : The model is well documented and tested. It provides good detail for a basin wide model and is consistent with Reclamation's interpretation of the "Law of the River".

WEAKNESSES: The model is site specific to the Colorado River and has substantial time and space requirements. It presently lacks sophisticated graphical capabilities.

INPUT REQUIREMENTS: Monthly hydrologic data (natural flow and salt data, gains and losses), projected demand data, area capacity and power generation parameters as well as specific parameters used to control reservoir operation and operating criteria. More detailed information is provided in the documentation.

OUTPUT PRODUCED: Streamflows, reservoir operations and power generation summaries, salinity estimates (in TDS) and deliveries to water users.

HYDROLOGIC **MODELS INVENTORY**

EVALUATION FORM

NAME OF MODEL: FAOP

FUNCTION: Provides a monthly simulation of the operations of the Eastern Slope Portion of the Fryingpan-Arkansas Project.

AGENCY & OFFICE: USBR Eastern Colorado Projects Office and USBR Denver Office

TECHNICAL CONTACT: Roger Weidelman (E700) 303-667-4410
Don Frevert (05755) 303-236-3809
FTS-776-3809

MACHINE COMPATIBILITY: CDC Cyber

DOCUMENTATION: Report entitled *Review of Operations, Fryingpan-Arkansas Project, Colorado,* U.S. Bureau of Reclamation, September 1990. Other materials in note form are available on request.

SPATIAL PRECISION: The model focuses on three major reservoirs (Turquoise, Twin Lakes and Pueblo) and provides hydrologic summaries for river reaches in between.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: The model schedules releases to meet demands, flow requirements and rule curves. It provides operational summaries of reservoirs, ownership of water by entity, gains and losses in reaches between reservoirs and flows at critical points within the basin. The model operates on the assumption of mass balance.

STRENGTHS: The model has been checked extensively for streamflow, reservoir content, ownership and other hydrologic calculations. It reflects Reclamation's interpretation of project operational procedures within the Arkansas Basin.

WEAKNESSES: The model is incapable of simulating water quality and lacks graphical capabilities. Power generation estimates have not been verified.

INPUT REQUIREMENTS: Monthly values for 27 hydrologic parameters including natural flows, imports, storable water, downstream demands and gains and losses. Rule curves, capacities, ownership limitations and initial conditions are set in the control portion of the input file. Municipal demands and certain other key variables are entered through data statements and "wired" code.

OUTPUT PRODUCED: Monthly and yearly summaries of flow, ownership, reservoir operations and gains and losses.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Bighorn Basin Annual Operating Plan Model

FUNCTION: Site specific monthly operations for Buffalo Bill, Boysen, and Bighorn Reservoirs.

AGENCY & OFFICE: USBR, Montana Projects Office (MTPO)

TECHNICAL CONTACT: Tim Felchle (MT-450) FTS-585-6516
406-657-6516

MACHINE COMPATIBILITY: VAX 6200 in Billings, MT

DOCUMENTATION: Specific model documentation in MTPO. General model documentation in Regional office, Attn: GP-1100.

SPATIAL PRECISION: Reservoir-by-reservoir for storage targets initially. Then looks at project as a whole to meet irrigation demands and to minimize spills.

TEMPORAL PRECISION: Monthly operations

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can simulate project operations for up to 10 years. Distribution of inflows is based on statistical analysis. Run for minimum, maximum, and probable inflow conditions.

STRENGTHS : Very good monthly operations model, hydrology and power operations simulated very accurately.

WEAKNESSES: Not as precise as a daily model during runoff season.

INPUT REQUIREMENTS: Inflows, reservoir storage targets, capability factors, irrigation demands, minimum releases, evaporation factors, initial month, year and storage.

OUTPUT PRODUCED: Inflows, pumped amount, river releases, turbine releases, bypass or spill, reservoir storage and elevation, evaporation, seepage, tunnel flows, max tunnel capacity, depletions, irrigation demands and releases, metered deliveries, max generation, actual generation, % of max generation, average KWH/AF, pump energy, min and max generations and corresponding durations, tunnel and release flexibility and corresponding generation.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF **MODEL:** North Platte Annual Operating Plan Model

FUNCTION : Site specific monthly operations for the North Platte, Kendrick, and Glendo Projects.

AGENCY & OFFICE: USBR, North Platte Projects Office (NPPO)

TECHNICAL CONTACT: Ed Kouma (C-405) FTS-328-5633
307-261-5633

MACHINE **COMPATIBILITY:** VAX 6200 in Billings, MT

DOCUMENTATION : Specific model documentation in NPPO. General model documentation in Regional office, Attn: GP-1100.

SPATIAL **PRECISION:** Reservoir-by-reservoir for storage targets initially. Then looks at project as a whole to meet irrigation demands and to minimize spills.

TEMPORAL PRECISION: Monthly operations

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can simulate project operations for up to 10 years. Distribution of inflows is based on statistical analysis. Run for minimum, maximum, and probable inflow conditions.

STRENGTHS : Very good monthly operations model, hydrology and power operations simulated very accurately.

WEAKNESSES: Not as precise as a daily model during runoff season.

INPUT **REQUIREMENTS:** Inflows, reservoir storage targets, capability factors, irrigation demands, minimum releases, evaporation factors, initial month, year and storage.

OUTPUT **PRODUCED:** Inflows, pumped amount, river releases, turbine releases, bypass or spill, reservoir storage and elevation, evaporation, seepage, tunnel flows, max tunnel capacity, depletions, irrigation demands and releases, metered deliveries, max generation, actual generation, % of max generation, average **KWH/AF,** pump energy, min and max generations and corresponding durations, tunnel and release flexibility and corresponding generation.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Colorado-Big Thompson Annual Operating Plan Model

FUNCTION: Site specific monthly operations for the CBT Project.

AGENCY & OFFICE: USBR, Eastern Colorado Projects Office (ECPO)

TECHNICAL CONTACT: Ed Everaert (E-1400) 303-667-4410

MACHINE COMPATIBILITY: VAX 6200 in Billings, MT

DOCUMENTATION: Specific model documentation at ECPO, Loveland, Colorado, Attn: E-1400. General model documentation at Regional office, Attn: GP-1100.

SPATIAL PRECISION: Reservoir-by-reservoir for storage targets initially. Then looks at project as a whole to meet irrigation demands and to minimize spills.

TEMPORAL PRECISION: Monthly operations

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can simulate project operations for up to 10 years. Distribution of inflows is based on statistical analysis. Run for minimum, maximum, and probable inflow conditions.

STRENGTHS: Very good monthly operations model, hydrology and power operations simulated very accurately.

WEAKNESSES: Not as precise as a daily model during runoff season.

INPUT REQUIREMENTS: Inflows, reservoir storage targets, capability factors, irrigation demands, minimum releases, evaporation factors, initial month, year and storage.

OUTPUT PRODUCED: Inflows, pumped amount, river releases, turbine releases, bypass or spill, reservoir storage and elevation, evaporation, seepage, tunnel flows, max tunnel capacity, depletions, irrigation demands and releases, metered deliveries, max generation, actual generation, % of max generation, average KWH/AF, pump energy, min and max generations and corresponding durations, tunnel and release flexibility and corresponding generation.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Fryingpan-Arkansas Project Annual Operating Plan Model

FUNCTION: Site specific monthly operations for features of the Fryingpan-Arkansas Project.

AGENCY & OFFICE: USBR, Eastern Colorado Projects Office (ECPO)

TECHNICAL CONTACT: Ed Everaert (E-1400) 303-667-4410

MACHINE COMPATIBILITY: VAX 6200 in Billings, MT

DOCUMENTATION: Specific model documentation in ECPO. General model documentation in Regional office, Attn: GP-1100.

SPATIAL PRECISION: Reservoir-by-reservoir for storage targets initially. Then looks at project as a whole to meet irrigation demands and to minimize spills.

TEMPORAL PRECISION: Monthly operations

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can simulate project operations for up to 10 years. Distribution of inflows is based on statistical analysis.

STRENGTHS: Very good monthly operations model, hydrology and power operations simulated very accurately.

WEAKNESSES: Not as precise as a daily model during runoff season.

INPUT REQUIREMENTS: Inflows, reservoir storage targets, capability factors, irrigation demands, minimum releases, evaporation factors, initial month, year and storage.

OUTPUT PRODUCED: Inflows, pumped amount, river releases, turbine releases, bypass or spill, reservoir storage and elevation, evaporation, seepage, tunnel flows, max tunnel capacity, depletions, irrigation demands and releases, metered deliveries, max generation, actual generation, % of max generation, average KWH/AF, pump energy, min and max generations and corresponding durations, tunnel and release flexibility and corresponding generation.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Western Division Power System Hydro-Power Summary Model

FUNCTION: Site specific monthly power operations for Western Division System.

AGENCY & OFFICE: USBR, Eastern Colorado Projects Office

TECHNICAL CONTACT: Ed Everaert (E-1400) 303-667-4410

MACHINE COMPATIBILITY: VAX 6200 in Billings, MT

DOCUMENTATION: Specific model documentation at ECPO. General model documentation in Regional office, Attn: GP-1100.

SPATIAL PRECISION: Powerplant-by-powerplant, summed up for the system.

TEMPORAL PRECISION: Monthly power operations

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Monthly power operations can be simulated for the Western Division System for up to 10 years. Assume monthly loads for Western Division Power System.

STRENGTHS : Very good monthly projection of power operations for hydropower plants in the Western Division System.

WEAKNESSES: Powerplant outages are difficult to show on a monthly basis when the outage is only for a portion of the month.

INPUT REQUIREMENTS: All of the input requirements except one are the output of the power operations derived from the four basin hydrology models enclosed. The monthly Western Division System power load is input.

OUTPUT PRODUCED: Base generation, load following generation, pump energy, total net generation, total system load, required energy imports, system surplus generation, power release flexibility, capacity and duration.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Western Division Annual Operating Plan

FUNCTION: Monthly water and power operation of the Western Division System Facilities

AGENCY & OFFICE: USBR, Eastern Colorado Projects Office (ECPO)

TECHNICAL CONTACT: R.E. Bellamy (E-1400) 303-490-7463

MACHINE COMPATIBILITY: VAX 6200

DOCUMENTATION: Specific model documentation in ECPO Joint Operation Center (E-1400)

SPATIAL PRECISION: See discussion in "Output Produced" section.

TEMPORAL PRECISION: Monthly simulation

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Program determines monthly hydropower operation of the Western Division system for one or more'years under various water supply conditions. Using current operating criteria, probable inflows, estimated system power loads and desired maintenance schedule, the program plans monthly operation to meet power load and water requirements.

STRENGTHS : Integrated nature of system operation

WEAKNESSES: Older Fortran language program

INPUT **REQUIREMENTS:** Requires inflows, power system loads, water delivery requirements and desired maintenance schedules.

OUTPUT PRODUCBD: Produces simulated monthly operating plan for twenty-two storage and regulating reservoirs and sixteen power plants. Summarizes individual plant and system gross and net generation. Displays system surplus or deficiency in energy to meet projected loads.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: PROSIM (PROJECT SIMULATION)

FUNCTION: Simulates operation of California's Central Valley Project and State Water Project

AGENCY & OFFICE: Bureau of Reclamation, Mid-Pacific Region, Division of Planning and Technical Services, Water Resources Branch

TECHNICAL CONTACT: Derek Hilts (MP-710) FTS-460-5124
916-978-5124

MACHINE COMPATIBILITY: PCs with 640 K of RAM. easily ported to other platforms

DOCUMENTATION: Contained within the code and by manual

SPATIAL PRECISION: Central Valley of California Subregions. Water Movement is not hydraulically determined.

TEMPORAL PRECISION: Monthly

OVERVIEW **OF** CAPABILITIES, ASSUMPTIONS: Simulates the two major water projects according to user specified reservoir operation rules, minimum flow requirements, M&I and agricultural demands. Simulation includes power computations and user specified pumping.

STRENGTHS : Tremendous flexibility in defining reservoir operation, minimum flow requirements, pumping and demands. Short execution time.

WEAKNESSES: No logic to prevent reservoir storages from going to zero. San Joaquin Basin is not fully integrated.

INPUT **REQUIREMENTS:** Inflows, local accretions, demands, reservoir operation criteria, minimum flow requirements, nodal relations, switch settings, power criteria, historic groundwater operation.

OUTPUT PRODUCED: Echo of input, shortages, storages, flows, calculated **pumpages,** accretions (calculated), in short all water balance items.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: SANJASM (SAN JOAQUIN AREA SIMULATION MODEL)

FUNCTION: Simulates operation of the San Joaquin River system of California's Central Valley plus the Calaveras River. Model is presently being finalized.

AGENCY & OFFICE: Bureau of Reclamation, Mid-Pacific Region, Division of Planning and Technical Services

TECHNICAL CONTACT: Dave Haisten (MP-710) FTS-460-4960
916-978-4960

MACHINE COMPATIBILITY: PCs with 640K of RAM, easily ported to other platforms

DOCUMENTATION: Some documentation within code, manual being developed.

SPATIAL PRECISION: Southern portion of California's Central Valley (ie San Joaq-uin and Calaveras River basins)

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Simulates the operations of Federal and private water projects and stream systems according to user specified reservoir operation rules, minimum flow requirements, demands for M&I and agricultural water and flood control. Simulation includes user specified pumping.

STRENGTHS : Tremendous flexibility in defining reservoir operations, minimum flow requirements, groundwater pumping and demands. Short execution time.

WEAKNESSES: No logic to prevent reservoir storages from going to zero.

INPUT **REQUIREMENTS:** Inflow, local accretions, demands, reservoir operating criteria, minimum flow requirements, groundwater pumpage, evaporation rates, nodal relations and switch settings.

OUTPUT PRODUCED: Echo of input, shortages, storages, flows, calculated groundwater pumpages, calculated accretions (all water balance items).

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF **MODEL:** CVGSM (CENTRAL VALLEY GROUNDWATER AND SURFACE WATER MODEL)

FUNCTION: To simulate water distribution/ movement throughout the entire Central Valley of California. This model is actually an application of the IGSM (Integrated Groundwater/Surface Water Model)

AGENCY & OFFICE: Bureau of Reclamation, Mid-Pacific Region, Division of Planning and Technical Services, Water Resources Branch.

TECHNICAL CONTACT: Jeff Sandberg or Derek Hilts (Ml?-710)
FTS-460-5124 or 916-978-5124.

MACHINE COMPATIBILITY: Fortran Code requiring 2+mb of RAM on 80386 based machine.

DOCUNNNTATION: Summary report for CVGSM, user's manual and documentation exist for IGSM

SPATIAL **PRECISION:** CVGSM model consists of 1392 elements covering the Central Valley floor. The average size of each element is 14 square miles. The finite element method is used. Precision limited by data. IGSM may be applied to any area and segmented into any number of subareas.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, **ASSUMPTIONS:** CVGSM assumes that most water use characteristics for the Central Valley can be described in terms of 21 regional units. It is capable of producing many mass balance budgets for each of the 21 regions.

STRENGTHS : This model lends itself to a wide range of modeling efforts when large scale questions are important. It is very flexible.

WEAKNESSES: The model is very data intensive and rather involved. It is not easily accessible to many first time users.

INPUT **REQUIREMENTS:** Extensive! Land use patterns, streamflow regimes, precipitation records, crop patterns, surface water diversions, groundwater pumping records and much more.

OUTPUT **PRODUCED:** Stream or groundwater hydrographs. Mass balance budgets for streamflow, groundwater, soil, land and water use, all by regional basis.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: FORCIS

FUNCTION: Operational forecasting model for Central Valley Project Water and Power Operations

AGENCY & OFFICE: USBR - MP Region - Central Valley Operations Office

TECHNICAL CONTACT: John Burke **W-2800)** 916-978-5232
FTS-460-5232

MACHINE COMPATIBILITY: CYBER (Fortran Code)

DOCUMENTATION: User's Manual (February, 1987). Includes summary description, input requirements, computational procedure and listing of code.

SPATIAL PRECISION: All outputs are' for discrete nodes.

TEMPORAL PRECISION: One month units, all outputs are either end of month, total monthly or average monthly.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: **"FORCIS"** is capable of describing the planned operations of the CVP for up to ten years in the future. The degree of detail required in developing inputs and running the model interactively make it practical for most purposes up to only a 12 month analysis.

STRENGTHS : The program permits the user to blend interactive decision making with rules and strategies that are coded into the model, thus simulating the flexibility often required in "real" project operations.

WEAKNESSES: Time consuming because of amount of input data development and relative complexity of running the model interactively. Accuracy of forecasting operations linked directly to accuracy of inputs. Accuracy tends to diminish with time.

INPUT REQUIREMENTS: Reservoir inflows, target storages and releases, unregulated system inflows, water delivery requirements, energy and power constraints.

OUTPUT **PRODUCED:** Tables of up to 12 months of forecasted water and power operations data for each of the Central Valley Project (CVP) facilities.

GLOBAL CLIMATE CHANGE RESPONSE PROGRAM

Hydrologic Models Inventory

Evaluation **Form**

NAME OF **MODEL:** Truckee - Carson Water Operations Model

FUNCTION: To provide management impacts to inflows to Pyramid Lake resulting from alternative diversions from the Truckee River.

AGENCY AND OFFICE: Bureau of Reclamation, Carson City, NV

TECHNICAL CONTACT: Robert W. Young, Mid-Pacific Region, Sacramento, CA

MACHINE **COMPATIBILITY:** 386 class microcomputer, FORTRAN 77 compiler, math coprocessor, and Denver's CYBER Computer System (outdated version). Program consists of over 50 subroutines and over 10,000 lines of code.

DOCUMENTATION: Documentation available for model of record, 1989. Changes to documentation have not been made to subsequent changes.

SPACIAL PRECISION: Truckee and Carson River Watershed areas. A comprehensive 1900-1989 historic data base exists for hydrologic parameters, inflows, precipitation, and evaporation.

TEMPORAL PRECISION: The model is run for either 80 or 89 years using actual hydrologic parameters. The model runs monthly. Model has been modified to run for a period of 200 years using "stochastically" created hydrology.

OVERVIEW **OF** CAPABILITIES, ASSUMPTIONS: Model keeps tract of water by month for period of record, either 80 or 89 years. Model output shows resultant conditions based on set of alternatives. Model has tremendous amount of flexibility in allocating the demands and matching sources of water.

STRENGTHS : The use by the Technical Advisory Team in making decisions. Team recognizes strengths and weaknesses. Use has been extensive in writing the Truckee Carson E.I.S. and subsequent negotiated settlement.

WEAKNESSES: Undocumented portion of the "black box" which determines historic depletions in the Truckee Meadows.

INPUT REQUIREMENTS: The model requires the following input files:
TCDATFIL, an 89-year historic hydrology file,
NCONCOF, an initial condition file,
NRUNDATA, a parameter file describing all of the options and switches, and
LINENAME, a file used to for writing the output file.

OUTPUT PRODUCED: Four pages of output for each model year. About 350 pages (2,000,000 bytes) produced for each run. File is usually scanned for key output values and then discarded.

HYDROLOGIC MODELS INVENTORY

EVALUATION **FORM**

NAME OF MODEL: BHOPS

FUNCTION: Lower Colorado River Daily Operation of Flow, Reservoirs and Power. Eight week projection, can project one year if needed.

AGENCY & OFFICE: U.S. Bureau of Reclamation, LC Region

TECHNICAL CONTACT: Alden Briggs (K-460) FTS-598-7677
702-293-8677

MACHINE COMPATIBILITY: Vax (written in Fortran)

DOCUMENTATION: Available, but may be somewhat outdated.

SPATIAL PRECISION: Focuses on reservoirs and delivery points in LC region.

TEMPORAL PRECISION: Daily

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Tracks lower basin water releases (Senator Wash, Imperial, Hoover, Davis and Parker), power produced, reach losses and gains, CAP, MWD and CRIR diversions, flow at imperial. This daily operation model assumes inflows as releases from upstream, the output is fairly accurate on a daily and monthly basis.

STRENGTHS: Gives good results on Hoover generation, gives a good idea of what may happen in the next two to four weeks of operation.

WEAKNESSES: Hand input model. The model is not easy to make changes to. It is not very "user friendly" (input, file structure, program, etc.) for first time users.

INPUT REQUIREMENTS: Needs approximately seven days of history to run. Also needs two month daily projection of downstream demands and firm energy.

OUTPUT PRODUCED: Projected eight weeks of daily flow, reservoir contents, diversions and power generation for Hoover, Davis, Parker and Senator Wash Dams. Can output up to a year if needed.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: 24-Month Study Model

FUNCTION: Produces Colorado River System 24 month projection of flow, reservoir contents, major diversions and power system generation.

AGENCY & OFFICE: U.S. Bureau of Reclamation, Lower and Upper Colorado Regions

TECHNICAL CONTACT: Alden Briggs (LC-460) FTS-598-7677
702-293-8677
Randy Peterson (UC-430) FTS-588-5571
801-524-5571

MACHINE COMPATIBILITY: Cyber System, Sun Work Stations

DOCUMENTATION: Some available

SPATIAL **PRECISION:** Focuses on key reservoirs and delivery points in the Colorado Basin.

TEMPORAL PRECISION: Monthly up to 24 months

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Primarily a monthly accounting model. Outputs supplies to lower basin and gives a way of tracking major changes in the Colorado Basin as the calendar year progresses. Release decisions are manually input.

STRENGTHS : Month-to-month evaluation of both upper and lower basin operations.

WEAKNESSES: Additional output points require Fortran programming.

INPUT REQUIREMENTS: 24-month projection of inflows, downstream demands, firm energy, forced releases, maintenance schedules, diversions and target contents.

OUTPUT PRODUCED: Projected 24 months of monthly flow, reservoir contents and elevation, power generation for 11 dams and major diversions.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: GLENREL

FUNCTION: Simulate operation of CRSP dams using actual existing strategies and forecasts

AGENCY & OFFICE: U.S. Bureau of Reclamation, Upper Colorado Regional Office

TECHNICAL CONTACT: Randy Peterson (UC-430) FTS-588-5571
801-524-5571

MACHINE COMPATIBILITY: IBM PCs and Vax

DOCUMENTATION: None available as of February, 1991. Model still being refined.

SPATIAL PRECISION: Focuses on CRSP dams

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Provides operational simulation of CRSP dams based on forecast information and operation strategies given as input.

STRENGTHS : Provides better operational simulation than CRSS

WEAKNESSES: Currently uses small number of input years (26) to run simulation.

INPUT REQUIREMENTS: Self contained

OUTPUT PRODUCED: Monthly releases, storage, power revenue generated.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Animas - La Plata Operation Study

FUNCTION: Provide river and reservoir operations for with and without project conditions.

AGENCY & OFFICE: USBR, Durango Projects Office, Durango, Colorado

TECHNICAL CONTACT: Errol Jensen, Gayle Brown FTS-323-6500
303-385-6500
David Read FTS-776-6240
303-236-6240

MACHINE COMPATIBILITY: CDC Cyber or VAX Computer

DOCUMENTATION: Complete Users Manual available with definitions of parameters, run instructions, column by column descriptions and sample input files.

SPATIAL PRECISION: Irrigation water delivery to nine areas ranging from 500 to 16,000 acres. Municipal water and industrial water delivery to four cities, two rural water districts and three Indian tribes. The various delivery points are shown.

TEMPORAL PRECISION: Daily

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Site specific operations. Has a somewhat unique capability to convert monthly consumptive use into daily irrigation requirements including soil moisture depletion, winter refill, preseason irrigation and other parameters. Regulates two storage reservoirs and two pumping plants. Calculates project water supply shortages based on available water supply.

STRENGTHS : Versatility and diverse capabilities.

WEAKNESSES : Extensive data requirements.

INPUT REQUIREMENTS: Very extensive daily and monthly data. Fairly extensive control input parameters.

OUTPUT PRODUCED: Monthly and daily column by column and monthly and yearly summaries. Has extensive "bells and whistles".

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Dolores Project Operation Study

FUNCTION: Provide river and reservoir operations for with and without project conditions.

AGENCY & OFFICE: USBR, Durango Projects Office, Durango, Colorado

TECHNICAL CONTACT: Errol Jensen, Gayle Brown FTS-323-6500
303-385-6570

MACHINE COMPATIBILITY: CDC Cyber or VAX Computer

DOCUMENTATION: Column by column description of output files and some description of sample input files.

SPATIAL PRECISION: Irrigation water delivery to 26,000 acres of supplemental service land and 27,860 acres of non-Indian and 7500 acres of Indian full service land. Municipal water supply to three communities, including Towaoc on the Ute Mountain Ute Indian Reservation, and a rural water district in the project area. Water is made available for fish and wildlife purposes and a fishery has been created below the main storage feature. The various delivery locations are shown.

TEMPORAL PRECISION: Monthly output

OVERVIEW **OF** CAPABILITIES, ASSUMPTIONS: Site specific operations. Yearly irrigation and municipal demands remain constant. The project water supply to the supplemental service land varies and is determined by the flow in the Dolores River during the irrigation season. Fishery releases also vary and are determined by the amount of water in the main storage reservoir at set decision points (different times of the year). Calculates project water supply shortages based on the available water supply.

STRENGTHS : Versatility and diverse capabilities.

WEAKNESSES : Calculations are done on a monthly basis. Requires extensive data. Logic is somewhat complicated and modification is difficult.

INPUT REQUIREMENTS: Very extensive daily and monthly data. Output from the pre-project operation study (operation without project conditions) is required to operate the project operation study (operation with project conditions). Requires fairly extensive control input parameters.

OUTPUT PRODUCED: Monthly column by column and monthly and yearly summaries. Has extensive "bells and whistles".

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: SRPSIM

FUNCTION: Simulates the operation of the system of reservoirs which are operated by the Salt River Project.

AGENCY & OFFICE: Salt River Project, Phoenix, Arizona

TECHNICAL CONTACT: SRP- John Keane (602) 236-5087
Reclamation - Mike Lee (APO-450) 602-870-6713
FTS-765-1713

MACHINE **COMPATIBILITY:** Program written in FORTRAN IV and run on SRP's IBM mainframe computer.

DOCUMENTATION: Available

SPATIAL PRECISION: Salt and Verde River Reservoirs

TEMPORAL PRECISION: Both input and output are given monthly per water year, beginning in October and ending in September.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: To simplify the modeling effort, the lower three reservoirs of the Salt River are treated as one. The program models Roosevelt, the Lower Salt, Horseshoe, and Bartlett Reservoirs. For a given water demand, the program determines the amount of groundwater and surface water required to satisfy that demand, based on historic reservoir inflows. The program then operates the reservoirs according to fixed operating criteria and performs accounting of the major SRP water contracts.

STRENGTHS : Useful as an aid in long term planning.

WEAKNESSES: Not especially helpful on a real time basis.

INPUT **REQUIREMENTS:** The program requires four input files which contain reservoir storage levels at Roosevelt and Horseshoe, annual water demands, contents-area-elevation data for each reservoir, and historic monthly inflow data.

OUTPUT **PRODUCED:** Monthly reservoir releases, losses, spills, contents, groundwater pumping, hydrogeneration and system water accounting.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF **MODEL:** CAPSIM

FUNCTION: Long range operations model for the Central Arizona Project.

AGENCY & OFFICE: USBR, Arizona Projects Office, Phoenix, Arizona

TECHNICAL CONTACT: Mike Lee (APO-450) 602-870-6713
FTS-765-1713

MACHINE **COMPATIBILITY:** USBR (Denver Office) CYBER computer.

DOCUMENTATION: Available

SPATIAL PRECISION: Focuses on reservoirs and delivery points in the Central Arizona Project.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: The model consists of two parts, DEMMOD and CAPSIM. DEMMOD models CAP water demands. Its output files are used by CAPSIM, along with Colorado River Simulation System (CRSS) hydrologic data, to model CAP operations. CAPSIM estimates seepage and evaporation losses from both the aqueduct and New Waddell Reservoir. Currently, 31 control points are modelled. Generation from New Waddell Dam is estimated, as well as lake elevations and volumes. Pump energy requirements are also estimated.

STRENGTHS : Especially useful for estimating project power needs and quantities of water delivered to CAP subcontractors based upon projected supplies from the Colorado River and projected demands.

WEAKNESSES: CAPSIM is difficult to make changes to. The model is not "user friendly." Therefore, "what-if" analyses are difficult to do.

INPUTREQUIRENENTS: CAP demand output from DEMMOD, a sister program residing on the USBR Denver Office CYBER. Also, historic hydrologic data from CRSS, called traces.

OUTPUT PRODUCED: Hardcopy or microfiche tables are produced for each hydrologic trace. Generally 16 CRSS hydrologic traces are used in a CAPSIM analysis. Currently, CAPSIM projects CAP operations up to the year 2034.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: YKMODEL (Version of USMD)

FUNCTION: Planning operation simulation for Yakima Basin

AGENCY & OFFICE: USBR, PN Region, Boise, Idaho

TECHNICAL CONTACT: Roger Larson (PN-708) FTS-554-9142
208-334-9142

MACHINE COMPATIBILITY: VAX Computer (written in FORTRAN).

DOCUMENTATION: Good for the present application.

SPATIAL PRECISION: Specified reservoirs and river locations.

TEMPORAL PRECISION: Monthly time increments. Runs on a water year basis.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Diversions are restricted according to basin specific water rights. Reservoir operation is demand driven or based on user defined **"opcodes".**

STRENGTHS : Flexibility in reservoir operation.

WEAKNESSES: User must dictate diversion entitlement for each year. Will not adjust diversions for lack of water supply.

INPUT REQUIREMENTS: Basin configuration, diversions and local gains for each time step.

OUTPUT **PRODUCED:** Wired for basin application. Standard "column" output. **WSP** type of tables. Utilities produce hydrographs, histograms, flow duration curves.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: Water Supply Forecasting (Snowmelt Runoff)

FUNCTION: Snowmelt runoff forecasting

AGENCY & OFFICE: USBR, Eastern Colorado Projects Office (ECPO)

TECHNICAL CONTACT: R.E. Bellamy (E-1400) 303-490-7463

MACHINE COMPATIBILITY: **VAX** 6200

DOCUMENTATION: Documentation in ECPO Joint Operation Center (E-1400)

SPATIAL PRECISION: Selected data station locations

TEMPORAL PRECISION: Seasonal (April-July) runoff volumes

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: The program procedures in multiple linear correlation are based on the Bureau of Reclamation's Engineering Monograph No. 2 by Perry Ford dated June 1953. Crout's method is used in solution of the linear equations.

STRENGTHS:

WEAKNESSES:

INPUT **REQUIREMENTS:** Primary input data is the observed station data for runoff, snow and precipitation for a given watershed. The program will handle up to 34 years of record.

OUTPUT PRODUCED: Listing of station data (input) along with actual and estimated runoff are compared for the period of record. Following the table of comparison, the forecast equations are shown for the average solution and best weighted solution. Values of the coefficient of correlation and standard error of estimate for each solution are shown.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: **TAMUWRAP,** The Texas A&M University Water Rights **Analysis** Program

FUNCTION: Water Rights Analysis

AGENCY & OFFICE: Department of Civil Engineering
Texas A&M University
College Station, Texas 77843

TECHNICAL CONTACT: Dr. Ralph A. Wurbs

MACHINE **COMPATIBILITY:** The model has been compiled for IBM PC microcomputers and VAX minicomputers. The FORTRAN 77 source code is available for compilation on any computer.

DOCUMENTATION: R.A. Wurbs, D.D. Dunn and W.B. Walls, "Water Rights Analysis Program **(TAMUWRAP)** Model Description and Users Manual," Technical Report 146, Texas Water Resources Institute, College Station, Texas, Draft, May 1991.

SPATIAL PRECISION:

TEMPORAL PRECISION: Monthly computational time interval with no limit on length of simulation period.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: The generalized computer model simulates the management and use of the streamflow and reservoir storage resources of a river basin under a prior appropriation water rights permit system.

STRENGTHS :

WEAKNESSES:

INPUT REQUIREMENTS:
1. Naturalized streamflows and reservoir evaporation rates,
2. water rights data including diversion and storage amounts, types of use and priorities and
3. reservoir characteristics and operating policies.

OUTPUT PRODUCED: Diversions, shortages, hydroelectric energy generated, streamflow depletions, unappropriated streamflows, reservoir storage levels and reliability statistics.

HYDROLOGIC **MODELS** INVENTORY

EVALUATION **FORM**

NAME OF MODEL: Water Operations Technology (WOT) set of models

FUNCTION: To simulate runoff (present and future) into a reservoir and to simulate the operations of a reservoir. Employs HECD55 data base

AGENCY & OFFICE: USBR - Denver Office - Facilities Engineering Branch

TECHNICAL CONTACT: Dave King (D-5210) 303-236-8322
FTS-776-8322

MACHINE COMPATIBILITY: IBM-PC and VAX

DOCUMENTATION: User's Manual; NWS and HEC manuals

SPATIAL PRECISION: Determined by user input

TEMPORAL PRECISION: Time series data from 15 minutes to 24 hours

OVERVIEW OF CAPABILITIES, **ASSUMPTIONS:** Can use either **HEC1F** or NWSSMA to simulate runoff. **NWSSMA** is better for day-to-day, but HEClF is useful in flood situations. Uses HEC precipitation weighting and forecasting. User has choice of two models to operate reservoir **(USBR** or **HEC5)** or can route a flood through reservoir.

STRENGTHS: Uses existing models. Interfaces to various data sources - WATSTOR, SHEF, SUTRON and HYDROMET.

WEAKNESSES: The HEC programs have a lot **of excess** baggage. The programs need to be streamlined to better use the PC. User interface can be improved.

INPUT **REQUIREMENTS:** Calibration coefficients, time series data.

OUTPUT PRODUCED: Predicted hydrographs, reservoir inflow and outflow.

HYDROLOGIC MODELS INVENTORY

EVALUATION **FORM**

NAME OF MODEL: PNMOD

FUNCTION: Generalized Streamflow Routing and Reservoir Operation Simulation

AGENCY **&** OFFICE: USBR, PN Region, Boise, Idaho

TECHNICAL CONTACT: Roger Larson (PN-708) FTS-554-9142
208-334-9142

MACHINE COMPATIBILITY: VAX Computer and Sun Work Station (written in-generic FORTRAN).

DOCUMENTATION: Available in September, 1991

SPATIAL PRECISION: Determined by user.

TEMPORAL PRECISION: Variable time steps (number of days).

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Progressive average streamflow routing, modified Puls reservoir routing. Return flows from diversions use streamflow routing logic.

STRENGTHS : Simple, flexible for most basin configurations.

WEAKNESSES : User must dictate reservoir releases. No decision logic.

INPUT REQUIREMENTS:

Standard Input: Average gains and diversions, basin configuration

Study Input: Percent of average gains and diversions, reservoir releases, beginning and ending study dates

OUTPUT PRODUCED: "Normal" column output, typically one month per page.
"Table" output - WSP type for one column of normal output. One year per page.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OR' **MODEL:** **DROPH** (Daily/Hourly Reservoir Operation)

FUNCTION: Simulates single or multi-reservoir operation based on "change **in** storage = inflow minus outflow"

AGENCY& OFFICE: USBR, Eastern Colorado Projects Office (ECPO)

TECHNICAL CONTACT: R.E. Bellamy (E-1400) 303-490-7463

MACHINE COMPATIBILITY: VAX 6200

DOCUMENTATION: Documentation in ECPO Joint Operation Center (E-1400)

SPATIAL PRECISION:

TEMPORAL PRECISION: Daily or hourly reservoir operation.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Program carries out daily or hourly reservoir operation. The program is based on the equation "change in storage = inflow - outflow." There is no operating criteria in the program and all inflows and outflows must be inputs. Inflow can be factored in order to vary total volume over a given period of time.

STRENGTHS :

WEAKNESSES: Data input intensive.

INPUT REQUIREMENTS: Inflow, outflow, reservoir area/capacity characteristics, initial storage, turbine characteristics, release capability of outlet facilities.

OUTPUT PRODUCED: Daily or hourly simulated reservoir operation including tabulation of inflow, reservoir storage and corresponding water surface elevation, outflow, evaporation and MWH generation.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF **MODEL:** WORK17C

FUNCTION: Single Reservoir Operation Study

AGENCY & OFFICE: USBR, Denver Office, Water Resources Section

TECHNICAL CONTACT: A. Emily Dowdy (D5752) 303-236-4044
FTS-776-4044

MACHINE COMPATIBILITY: Personal Computer

DOCUMENTATION: User's Manual with sample input and output and program listing

SPATIAL **PRECISION:** Single Reser-oir

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, **ASSUMPTIONS:** The program has two demand options: firm yield and set demand with shortages or excess storage allowed.

STRENGTHS : Well documented and tested.

WEAKNESSES: Has annual demand with monthly factors, neither one varies from year to year.

INPUT **REQUIREMENTS:** Parameters as explained in user's manual. Area-capacity curve or table, evaporation rate in feet, flow in acre-feet or 1000 acre-feet. Can have more than one set of inflows, for example intervening flow and spills from upstream reservoirs.

OUTPUT PRODUCED: Annual summary, monthly printout of evaporation rate, lake evaporation, demand, shortage, spills, end of month volume and area, beginning of month area. If more than one set of inflow, table is produced showing all inflows.

RYDROLOGIC MODELS INVENTORY

EVALUATION **FORM**

NAME OF MODEL: River Network Model

FUNCTION: The River Network Model is a generalized, data driven, accounting model for streamflow and salinity. The model works on a monthly basis with a flexible structure that simulates the basin by river reaches, junctions and reservoirs.

AGENCY **& OFFICE:** USBR **-** Denver Office **-** Groundwater Branch

TECHNICAL CONTACT: Dick Ribbens (D5740) **303-236-3812**
FTS-776-3812

MACHINE COMPATIBILITY: Control Data Cyber Computer (written in Fortran IV)

DOCUMENTATION: Ribbens, Richard W. "Program NW01, River Network Model, Users Manual," U.S. Bureau of Reclamation, Denver, Colorado, July 1973, revised March 1975.

SPATIAL PRECISION: Determined by the user and the reach structure he/she specifies.

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: In addition to reservoir and river basin accounting, the model can be used to simulate irrigation, water consumption, imports, exports and salinity control projects. It assumes that salinity can be treated as a conservative parameter using a mass balance approach. Instantaneous mixing within the reservoir is also assumed. Reservoirs are operated based on demands and release rules which consider flood control and other operational requirements. It does not presently have the capability to model power generation or off stream storage.

STRENGTHS : The model is technically sound, very flexible and has been applied to a wide variety of river basin management problems, It offers sophisticated error checking options.

WEAKNESSES: The model has been unused for the past several years and needs to be adapted for use on personal computers.

INPUT REQUIREMENTS: River basin structure, reservoir parameters (including area-capacity, bank storage coefficients, evaporation rates, initial conditions and operational criteria), water and salt flows, gains and losses, imports and demands (including exports).

OUTPUT PRODUCED: Reservoir inflows, contents and releases, water and salt flows at key points or junctions in the river basin, deliveries, consumption and return flow for individual demands.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: HYDROSS-Hydrologic River Operations Study System

FUNCTION: A surface water supply model developed to assist in planning studies for evaluating existing and proposed demands on a river system.

AGENCY & OFFICE: U.S. Bureau of Reclamation, Great Plains Region, Planning Division, Billings, Montana

TECHNICAL CONTACT: Kip Gjerde/Scott Boelman (GP-730) 406-657-6248
FTS-585-6248

MACHINE COMPATIBILITY: IBM PC Compatible, CDC Cyber Mainframe

DOCUMENTATION: Full documentation entitled "Hydross Version 4.00" distributed by Information Resources Division, U.S. Bureau of Reclamation, Billings, Montana, Draft Version, January 1991.

SPATIAL PRECISION: Any size drainage basin, canal system

TEMPORAL PRECISION: Monthly

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: A system of computer programs for use in conducting monthly water supply studies. HYDROSS operates on input data in a strict sequential order in time (results from one month depend on the system state of the previous month), space (results at one station depend on what is happening upstream and/or downstream), and priority (earlier water rights are allowed water before later water rights). HYDROSS is a monthly accounting model.

STRENGTHS : Operates on a priority system for water demands and is very flexible, allowing the user to rapidly conduct "what if" studies. HYDROSS has many options for water use demands.

WEAKNESSES : Does not model groundwater or other conjunctive uses. Does not have a forecasting mode for reservoir operations.

INPUT REQUIREMENTS: Three types of data files: flow, table and network. The flow file contains pristine monthly flow data. The table file is a means for introducing operational parameters into the model. The network file contains a physical description of the study area.

OUTPUT PRODUCED: Results can be output in fixed format text files and/or a "comma and quotes" file which can be loaded into graphics producing software.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: **PNRRN**

FUNCTION: Monthly Simulation of Reservoirs and River Systems

AGENCY & OFFICE: USBR - PN Regional Office, Boise, Idaho

TECHNICAL CONTACT: Jim Doty (PN471) FTS-554-1339
208-334-1339

MACHINE COMPATIBILITY: CDC Cyber (written in **Fortran** IV) Could probably be converted easily to any system with a **Fortran** compiler.

DOCUMENTATION : **5** pages including input field descriptions and schematics showing runoff computation methods.

SPATIAL PRECISION: **25** streamflow control points, any of which may be reservoirs.

TEMPORAL PRECISION: Monthly - No limit on number of years.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: The model focuses on water accounting and allows for prioritization of diversions. Information on the workings of the model is somewhat limited and it is not currently in use by anyone. The source code is available to anyone interested in studying it.

STRENGTHS : Simple, small program

WEAKNESSES: Not used recently. Needs some study and review.

INPUT REQUIREMENTS: Formatted hydrologic data

OUTPUT PRODUCED: Hydrologic output in "printout" or file form for selected control points.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: OPSTUDY

FUNCTION: OPSTUDY is a utility program developed to assist the hydrologist to program a monthly water operation study. It provides the following:

1. Reads input data.
2. Zeros all computation and summary arrays.
3. Totals monthly data into annuals.
4. Stores and accumulates summary data.
5. Computes net lake evaporation from a reservoir.
6. Computes channel evapotranspiration salvage and local ground water depletions resulting from (negative) river flows.
7. Computes groundwater return flow from an irrigated area.
8. Prints a descriptive summary of all constants and initial values.
9. Prints monthly data for each year with annual totals and line headings.
10. Prints average monthly data and annual totals for the period of study.
11. Prints summary tables of selected monthly data.
12. Saves selected summary tables in machine readable form in a user named file.
13 Generates plot files of selected summary tables.
14. Provides piece wise linear interpolation of a curve linear function.
15. The user programs a Computation subroutine to do the necessary water operation analysis.

AGENCY & OFFICE: Bureau of Reclamation
Nebraska Kansas Projects Office
Grand Island, NE

TECHNICAL CONTACT : Duane Woodward
North Platte River Projects Office
Mills, WY 82644 (307-261-5608)

MACHINE COMPATIBILITY: Program available in Fortran IV on Cyber - EE, Fortran 77 on Grand Island VAX 330 also Mills VAX 750, and Fortran for PC using Microsoft Fortran compiler in Grand Island, NE.

DOCUMENTATION: There is a USER's Manual that discusses using the program, describes the input data and gives example input and output. The manual was developed by Fred Otradovsky and dated 8-26-1986.

SPATIAL PRECISION: Water operation studies can be programmed for large river basins or a single reservoir. The number of river basin reaches calculations are made for is variable.

TEMPORAL PRECISION: OPSTUDY does monthly time step computation for a variable number of years up to 100.

OVERVIEW OF CAPABILITIES ASSUMPTIONS: This utility program provides the means to do a monthly water operation analysis of a river basin as complicated as the user requires. It is limited by what operations a user can describe in **Fortran.** The assumptions of water operations are developed by the user as the operation study model is being built.

STRENGTH : The flexibility to describe the water operations of any river basin. The input and output of the program are standardized but variable for each river basin operation.

WEAKNESSES: The user has to develop **Fortran** subroutine to describe the water operations in a river basin. This has been made easier though with a **Fortran** program called **GENCOMP** and GENFORM that writes **Fortran** statements for the user in the Compute subroutine standardized format including a program dictionary of each variable used.

INPUT **REQUIREMENTS:** The inputs vary based on the water operations being done. The basic types of inputs are study title, output line headings, water operation description, constant values (for example starting reservoir content), constant monthly values (for example reservoir evaporation rate), and month by year data values (for example monthly inflows to reservoir). The month by year input can be assembled from a data base by a program called BUILD.

OUTPUT PRODUCED: Monthly data by year for each water operation variable setup in the program by the user (for example flow at a gaging station). Annual totals for the variables and period summaries. Also table data of user defined variables and machine readable files of variables for use in other programs or plotting programs.

HYDROLOGIC MODELS **INVENTORY**

EVALUATION FORM

NAME OF MODEL: Streamflow Synthesis and *Reservoir* Regulation **(SSARR)** Model

FUNCTION: Watershed model, lake/reservoir model, and streamflow model integrated with hydrologic data processing system.

AGENCY & OFFICE: U.S. Army Corps of Engineers, NPD; Water Management Division

MACHINE COMPATIBILITY: IBM-PC-compatible requiring **390K** free RAM and about 3 megabytes of hard disk. Program is in FORTRAN and has been installed on many hosts including IBM, DEC, and HARRIS.

DOCUMENTATION: User Manual incorporating discussion and examples.

SPATIAL PRECISION: **No** restriction

TEMPORAL PRECISION: Minimum time step is 0.1 hour **(6** minutes).

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Watershed model may simulate rain runoff, snow accumulation, and snow melt. Snow simulation accounts for snow cold content and liquid water, and seasonal conditioning for melt. Runoff simulation accounts for evapotranspiration, soil moisture, **baseflow** infiltration, and routing into the stream system.

River model routes streamflows through channel and lake storage, and simulates reservoir operations. Diversion, overbank, and backwater effects may be simulated.

INPUT REQUIREMENTS: Most input data is prepared in **80-column** images; some in fixed-column format, and some in a positional-free format. Program includes an interactive mode providing prompts and help messages.

OUTPUT **PRODUCED:** Printouts, in both 80 and 132 column widths, of detailed model results as well as **summaries,** as designated by the user. A permanent work file may be maintained on direct-access storage for daily operations.

HYDROLOGIC MODELS INVENTORY

RVALUATION *FORM*

NAME OF MODEL: HEC-5

FUNCTION: Simulates sequential operation of a reservoir-channel system using a branched network configuration.

AGENCY & OFFICE: U.S. Army, Corps of Engineers Hydrologic Engineering Center
609 Second St.
Davis, California 95616

TECHNICAL CONTACT: Hydrologic Engineering Center 916-756-1104

MACHINE COMPATIBILITY: Personal Computer

DOCUMENTATION : This program has been documented by **"HEC-5,** Simulation of Flood Control and Conservation Systems (1982, rev. 1983) and supplemental documents.

SPATIAL PRECISION: Determined by the user's formulation of specific reservoirs, diversions and control points.

TEMPORAL PRECISION: Time intervals can vary from 1 minute to 1 month. It is also possible to use multiple time intervals within a single simulation.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Can perform channel routing by any of seven hydrologic routing techniques. Reservoirs can be operated to minimize downstream flooding, evacuate flood control storage as quickly as possible, provide for low-flow requirements, and meet hydropower and diversion requirements. Accessory programs are available to assist the user.

STRENGTHS : The program is well maintained, versatile, technically sound and widely accepted.

WEAKNESSES: The program can require a substantial amount *of* time to execute on 286 class machines. However, with extended virtual memory and overlays on 386 class machines, execution time can be reduced substantially to a point comparable with mainframe computers.

INPUT REQUIREMENTS: Input includes generally descriptive parameters as well as time series data. The general parameters reflect overall system configuration, reservoir and control point locations, streamflow and reservoir routing preferences and reservoir operation rules. Time series data includes, among others, streamflow, evaporation and diversion requirements.

OUTPUT PRODUCED: Considerable flexibility is available to the user in selecting which parameters to display. Primary items include reservoir and streamflow data as well as economic output.

HYDROLOGIC **MODELS INVENTORY**

EVALUATION FORM

NAME OF MODEL: S IMULOP

FUNCTION: Generalized simulation of river and reservoir operations. Presently set up for Flathead-Clark's Fork River system.

AGENCY & OFFICE: USBR, PN Region, Boise, Idaho

TECHNICAL CONTACT: Jim Doty (PN-471) FTS-554-1339
208-334-1339
Roger Larson (PN-708) FTS-554-9142
208-334-9142

MACHINE COMPATIBILITY: VAX Computer (written in FORTRAN). Probably an easy conversion to other systems with FORTRAN compilers (including PCs).

DOCUMENTATION: Substantial documentation available.

SPATIAL PRECISION: 40 reaches, 4 reservoirs as presently dimensioned.

TEMPORAL PRECISION: Maximum of 24 periods per year. Usually used as a monthly (12 period) model.

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Flood control, irrigation M&I, water quality, fish and wildlife and hydropower. Diversion demand utilities to alter demands.

STRENGTHS : Versatile and fairly simple to customize for a basin, if needed.

WEAKNESSES: No water allocation/water rights accounting. Code needs some work in output formats if more than 14 periods per year are used. Code must be wired in to handle flood control.

INPUT REQUIREMENTS: Diversion and local gains file, basin configuration file.

OUTPUT **PRODUCED:** "Printout", up to 50 output variables. Special output of total diversions, shortages. Output wired for each application.

HYDROLOGIC MODELS **INVENTORY**

EVALUATION **FORM**

NAME OF MODEL: Interactive River Simulation Program (IRIS)

FUNCTION: Simulation of river flows, natural lake and reservoir storage volumes, pollutant concentrations and hydroelectric energy production.

AGENCY **& OFFICE:**
Resources Planning Associates
231 Langmuir Lab
Cornell Research Park
Ithaca, NY 14850

Civil & Environmental Engineering
Hollister Hall
Cornell University
Ithaca, NY 14853-3501

TECHNICAL CONTACT: Daniel P. Loucks (Cornell University)
607-255-4896 (Phone)
607-255-9004 (Fax)

MACHINE COMPATIBILITY: PC-XT,AT,PS/2 compatible (DOS 3.0+); VAXStation (VMS)

DOCUMENTATION: User's and General Description manuals

SPATIAL PRECISION: User-defined

TEMPORAL PRECISION: User-defined, but not short term flood events

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Permits the simulation of water quantities and qualities, and hydropower in any river system drawn in by the user. The operating policy is defined by reservoir release rules and allocation functions, together with multiple reservoir storage distribution targets for reservoirs operating as a group. Reach flow routing is available, but not recommended for flood flow simulations. Most assumptions are in the input data, and can therefore be easily changed.

STRENGTHS: Flexibility and ease of use; adaptability to a wide variety of single or multiple river systems.

WEAKNESSES: Circular loops, pumped storage over multiple within-year periods, and flood flows cannot be simulated. Additional programs are needed to perform economic and other nonhydrologic analyses at specific sites.

INPUT REQUIREMENTS: The configuration of the system is specified by "drawing in" nodes (reservoirs, inflow sites, junctions and other key locations) and interconnecting links (river reaches, canals, etc.). In addition, the following general data is entered:

Threshold values representing satisfactory or unsatisfactory ranges for "state" variables (flows, pollutant concentrations, lake and reservoir storage volumes and energy production levels), number and length (days) of each within-year period, number of years of simulation.

Flows and Storage Volumes:

Surface area - elevation functions for storage reservoirs and natural lakes and elevation - discharge functions for natural lakes, Ratios of appropriate natural flows at each non gauge site to the natural flow at the appropriate gauge site, evaporation and other losses for all lakes and reservoirs, evaporation and other losses in all stream reaches as a function of streamflow, values of flow routing parameters in river reaches where flow time exceeds the within year time period, initial storage volumes, release rules for groups of jointly operated reservoirs and for single reservoirs operated independently (number and location of storage zones, their respective releases, the number of release adjustment decision times within each within-year simulation period), reservoir storage balancing functions for reservoir groups, allocation functions of flow at diversion and water use allocation sites as a function of total flow available at the diversion site.

Hydroelectric Power:

Powerplant capacity, hydroelectric plant factors indicating the fraction of each within-year time period energy can be produced, energy production coefficients (including efficiency) that convert storage head and turbine flow to energy, pumped storage factors for each within year time period.

Quality:

Time of flow as a function of flow for each reach, constituent transformation and decay rate constants, initial concentrations of each constituent at the outlet of all lakes and reservoirs.

Data read through files includes:

One or more sequences of flows at gauge sites in each within-year period for each year of simulation, names of quality constituents being simulated, and the mass loadings of each constituent at each node.

OUTPUT PRODUCED: Time series plots of quantities, qualities and energy produced at any node or link of the river system network, tabular and probability distribution displays of magnitude and duration of "failure" events as defined by the user, formatted files of all simulation results.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: MODSIM

FUNCTION: Generalized river basin network simulation model for hydrologic and water rights analysis in complex river basin systems; includes stream-aquifer model for conjunctive use of surface and groundwater.

AGENCY & OFFICE: Department of Civil Engineering, Colorado State University

TECHNICAL CONTACT: John W. Labadie, Professor - 303-491-8596

MACHINE COMPATIBILITY: IBM or compatible PC version available: UNIX-based workstation version also available, currently running on VAX/DEC Stations under ULTRIX; version also running on DEC VAX 11-780.

DOCUMENTATION: User Manual available which includes theoretical basis, numerical aspects and example usage based on actual case studies. Also, a number of technical papers are available describing usage of MODSIM for a variety of case studies.

SPATIAL PRECISION: Current PC version allows specification of up to 100 nodes and links to describe river basin network; UNIX workstation version allows up to 1000 nodes and links.

TEMPORAL PRECISION: Allows monthly, weekly and daily time increments; up to 50 year simulation runs allowed for monthly time step.

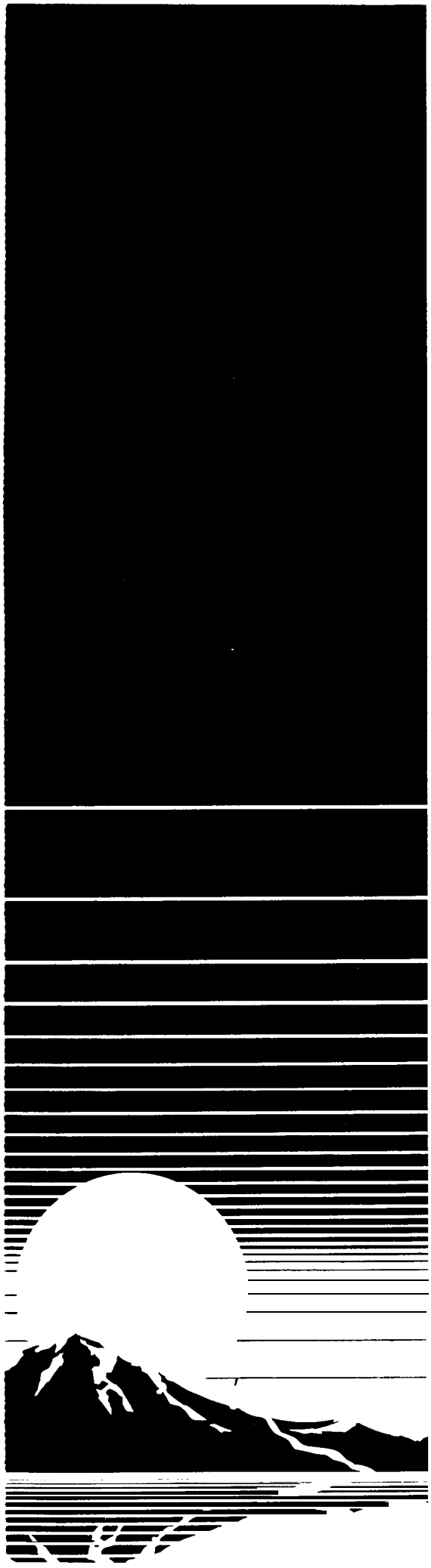
OVERVIEW OF CAPABILITIES, ASSUMPTIONS: The most current PC version of the model employs an efficient Lagrangean relaxation strategy for solving least-flow networks as an efficient means of allocating water according to complex water right provisions; allows consideration of exchanges, transfers and plans for augmentation; considers hydropower systems and instream uses.

STRENGTHS: MODSIM is unique in its ability to solve complex river basin management problems'with consideration of water rights; MODSIM has been adopted by numerous agencies and water organizations and successfully applied to many basins.

WEAKNESSES: MODSIM is currently not suitable for flood control operations or real-time operations requiring surface flow routing; user manual and documentation is in need of upgrading and improvement.

INPUT **REQUIREMENTS:** Physical network structure: reservoirs, stream reaches, canals, pipelines, pumping stations, hydro plants, wells, demands; hydrologic information on unregulated system inflows, demands, evaporation, rainfall, and energy generation; also requires water rights priorities and other information on prioritizing water allocation.

OUTPUT PRODUCED: Screen displays and hardcopy output of reservoir balances, inflows and releases, system losses, and hydrogeneration; link flows, groundwater recharge and pumpage; and demand satisfaction from groundwater and surface water; printer plots of system storage and flows, as well as true graphics screen output (CGA/EGA/VGA) on most of the above output items. Summary information is also available on hydrogeneration, demand shortages and firm energy and water supply.



CATEGORY IV

Category **IV**

Other Related Models

Three general purpose models related to water distribution, which could have applications for two of the above categories, were inventoried by the Bureau of Reclamation (BOR), and planning and management consultants, and are presented in this separate category.

Name of Model	Organization
WATER (Steady State Pipe Hydraulics)	BOR
WATEXT (Pipe Hydraulics Overtime)	BOR
IWRMAIN (Municipal and Industrial Water Use Forecasts)	Consultants

BYDROLOGIC MODELS INVENTORY

EVALUATION *FORM*

NAME OF MODEL: WATER

FUNCTION: Pipe hydraulics (steady state)

AGENCY & OFFICE: USBR Denver Office, Water Resources Section

TECHNICAL CONTACT: John Osterberg (D5752) 303-236-5218
FTS-776-5218

MACHINE COMPATIBILITY: IBM or compatible PC

DOCUMENTATION: User manual available with examples

SPATIAL PRECISION: Determined by user through node specifications.

TEMPORAL PRECISION:

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Program is designed to model hydraulics of municipal water systems.

STRENGTHS : It is capable of evaluating pumps, PRV, PRSV, reservoirs, pipes and wells.

WEAKNESSES:

INPUT **REQUIREMENTS:** Pipe parameters (length, C Factor, diameter, nodes), demand, elevation, pump curves, FWE for at least one point in the system.

OUTPUT PRODUCED: Velocity, pressure, flows and where pumps are operating on pump curves. Excellent graphic presentation. Downloads to CADD.

HYDROLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF MODEL: WATEXT

FUNCTION: Pipe hydraulics (over time)

AGENCY & OFFICE: USBR Denver Office, Water Resources Section

TECHNICAL CONTACT: John Osterberg (D5752) 303-236-5218
FTS-776-5218

MACHINE COMPATIBILITY: IBM or compatible PC

DOCUMENTATION:

SPATIAL PRECISION: Specified by user through node structure.

TEMPORAL PRECISION:

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: Program is designed to evaluate pipe systems over time. Capable of checking operating ranges of pumps and efficiencies of municipal reservoirs.

STRENGTHS :

WEAKNESSES:

INPUT REQUIREMENTS: Pipe parameters (Length, C Factor, diameter, nodes), demand, elevation, pump curves and FWE.

OUTPUT PRODUCED: Includes velocity, pressure, flows and where pumps are operating on pump curves. Excellent graphical presentation. Downloads to CADD.

BYDBOLOGIC MODELS INVENTORY

EVALUATION FORM

NAME OF **MODEL:** IWR-MAIN, Water Use Forecasting System, Version 5.1

FUNCTION: Forecasting desegregate municipal and industrial water demand and estimating impact of demand management measures

AGENCY & OFFICE: Mr. W. Davis
Planning and Management Consultants, Ltd.
Route 9, Hwy 51 South, Box 15
Carbondale IL 62901

TECHNICAL CONTACT: Mr. W. Davis

MACHINE COMPATIBILITY: IBM Compatible PC with DOS 2.0 or higher

DOCUMENTATION: IWH-MAIN Water Use Forecasting System, Version 5.1, User's Manual and System Description, June 1988, IWR Report 88-R-6

SPATIAL PRECISION: User-defined, county, service area, pressure zone, etc.

TEMPORAL PRECISION: User-defined, up to 50 years from base year

OVERVIEW OF CAPABILITIES, ASSUMPTIONS: The IWH-MAIN System provides sectorally, spatially, and seasonally desegregate water use forecasts. Water use sector include residential, commercial, industrial, and public/unaccounted for water users. Water use forecasts are generated with and without the impact of water conservation measures. Water use is estimated based on determinants of water use such as price of water, home values, weather and employment.

STRENGTHS : The IWH-MAIN System may be used for system planning and conservation evaluation.

WEAKNESSES: Significant socioeconomic data inputs are required to properly reflect water use characteristics of a study area.

INPUT REQUIREMENTS: Inputs included base year housing units by value range and type, price of water, density of units per acre, persons per household and employment data by commercial and industrial categories. Inputs also include population, total employment and median household income for all forecast years.

OUTPUT PRODUCED: Output consists of desegregate water use forecasts by sector, season, and individual user category for the base year and each forecast year. The forecast is provided both with and without the effect of specified conservation measures. The impact of individual conservation measures by sector and dimension of use is also provided in a separate output file.

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